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SPECIFICATIONS FOR IDAMST SOFTWARE.(U)
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UNCLASSIFIED AFAL-TR-76-208-VOL-1 NL

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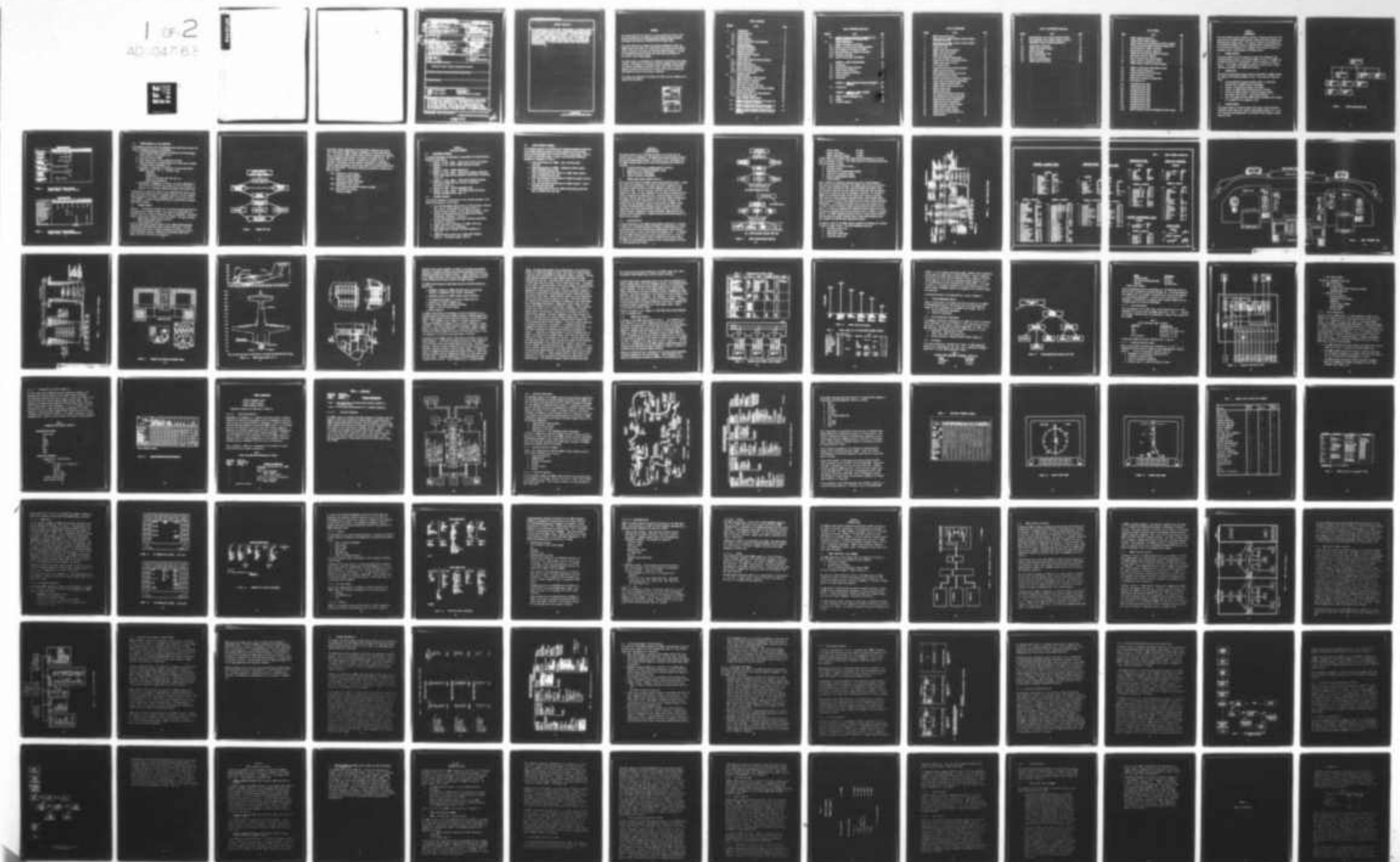

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Air Force Avionics Laboratory (AAA)
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## ABSTRACT (Continued)

[illegible]

# FOREWORD

This report describes the results of a study performed for the Air Force Avionics Laboratory by the Boeing Aerospace Company, Military Airplane Development under Contract F-[illegible] of Project [illegible].

The report describes the software documentation developed to define the [illegible] system for the [illegible]. The report details the approach used to define, design, and specify the ground and flight operational programs. The work was performed during April through June 1976, under the direction of Mr. David G. [illegible], Program Manager.

The author wishes to acknowledge the significant contribution to the program of Messrs. John Andrews, Al Crossgrove, [illegible] Cunningham, Harvey [illegible], Paul [illegible], Joe [illegible], Doug Smith, and Dr. Leroy Smith of The Boeing Company, Jim Gracie and William Hirt of Harris [illegible], and Larry [illegible] and Gary [illegible] of the Air Force Avionics Laboratory.

This report was submitted by the author July 1976, has been reviewed, and is approved for publication.

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## SECTION I

## INTRODUCTION

This final technical report documents the Phase I technical activity for the Specification for IDAMST Software contract (F33615-76-C-1099) awarded to the Boeing Aerospace Company (BAC). The study was conducted by the Boeing Military Airplane Development, Avionics Technology under the sponsorship of the Air Force Avionics Laboratory and in support of their effort to specify a candidate avionics system design for the AMST aircraft.

### 1.1 PROGRAM OBJECTIVE

The primary objective of this study was to specify the software for the Integrated Digital Avionics for the AMST (IDAMST) aircraft. The IDAMST system baseline definition is specified in a series of documents as shown in Figure 1. The software specifications (noted by the bold lines of Figure 1 represent one element of the IDAMST specification.

### 1.2 PROGRAM TASKS

The specific program tasks directed towards specification of IDAMST software are stated in the contract statement of work. These tasks are summarized below.

a. Develop Operational Sequence Diagrams (OSD's) to facilitate determination of IDAMST software requirements.
b. Develop a reconfiguration approach for IDAMST.
c. Analyze the IDAMST System Hardware/Software interfaces
d. Specify the IDAMST software by means of Computer Program Development Specifications - type B5 (MIL-STD-490).
e. Revise and expand the AFAL IDAMST Software Management Plan supplied as an appendix to the statement of work.

### 1.3 PROGRAM SCHEDULE

The program schedule is shown in Figure 2 and Figure 3 for the specified statement of work (SOW) tasks (noted by SOW Paragraph numbers 4.2.1, 4.2.2, etc.) and associated documentation. The technical effort spanned a 4 month period of time.

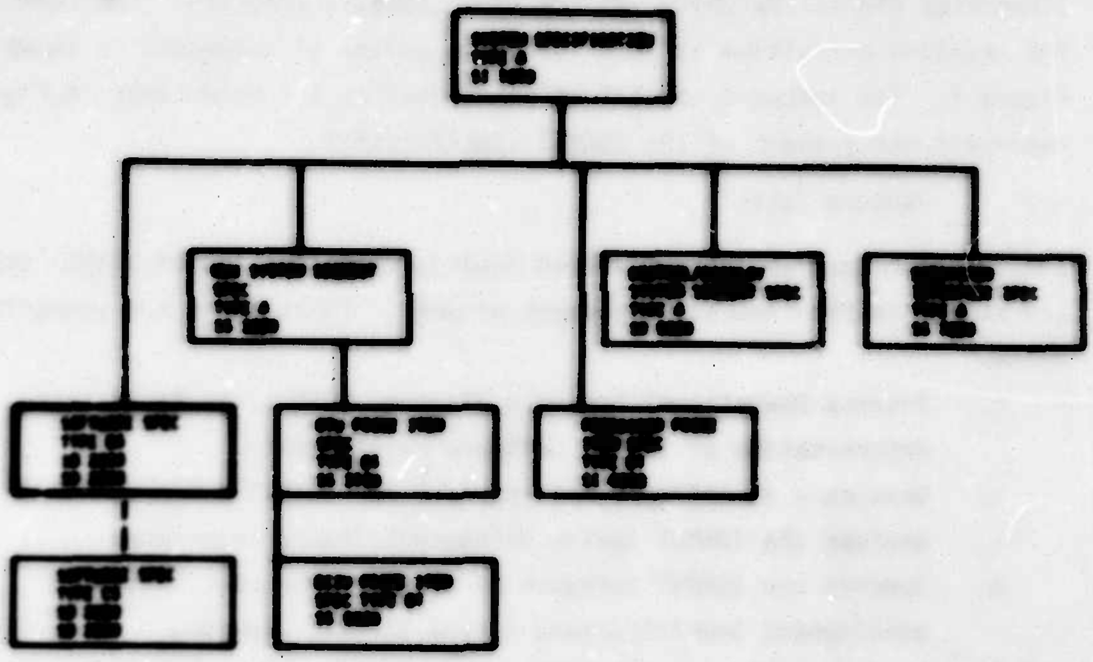


FIGURE 1. [illegible] SPECIFICATION TREE

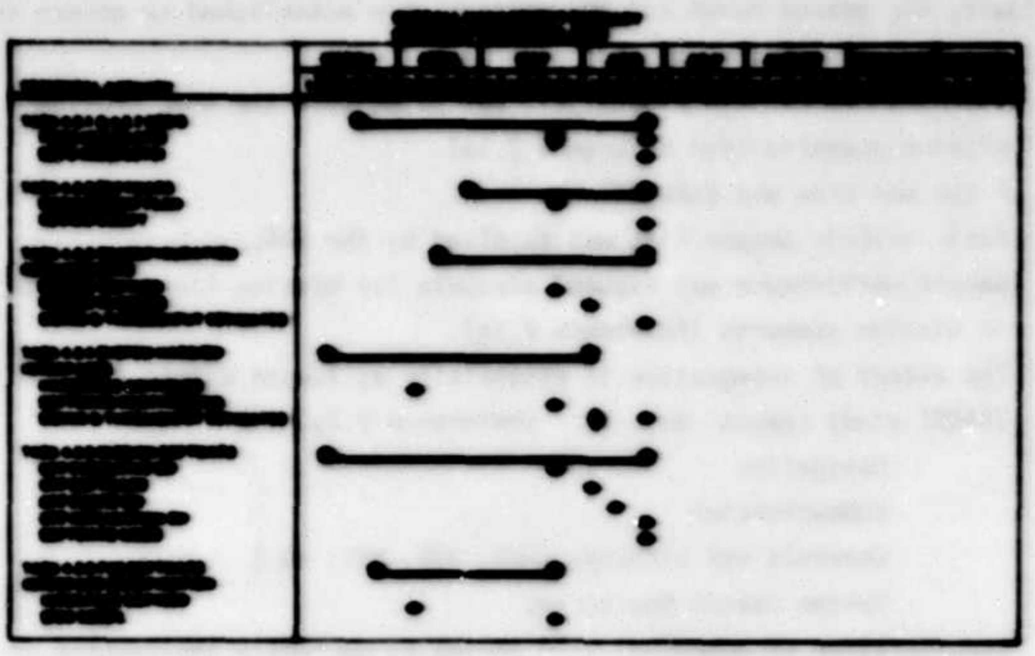


FIGURE 2. SPECIFICATION OF [illegible] SOFTWARE PROGRAM SCHEDULE ( TECHNICAL ACTIVITY)

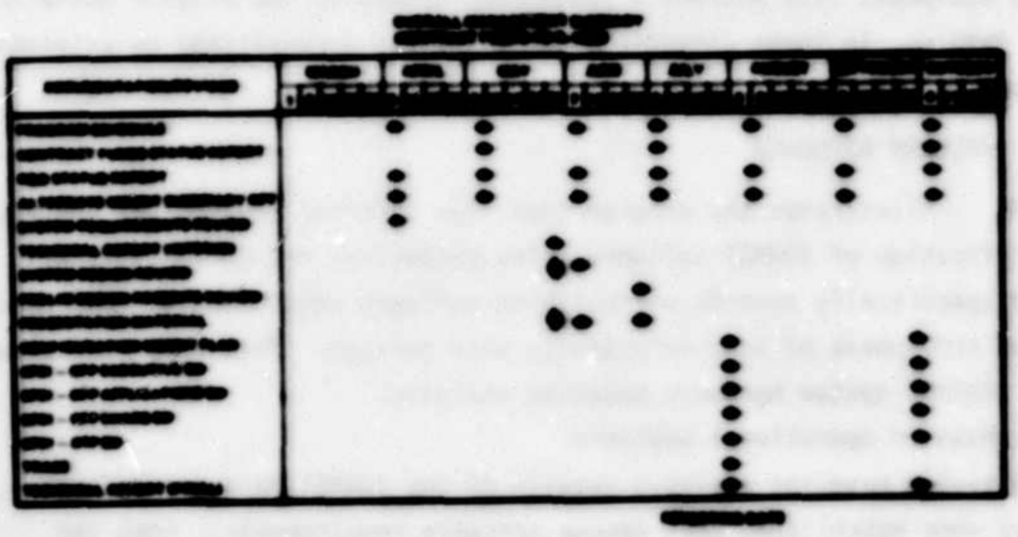


FIGURE 3. SPECIFICATION OF [illegible] SOFTWARE PROGRAM SCHEDULE ( DOCUMENTATION/REVIEW)

## 1.4 PROGRAM GROUND RULES AND ASSUMPTIONS

The following key ground rules and assumptions were established to govern the conduct of technical activity on this program.

a. The mission/operational analysis was based upon the AFAL provided mission scenario (See reference 2.1a).

b. A two man crew was assumed.

c. Basic avionic sensor list was supplied by the AFAL.

d. Sensor performance was assumed adequate for mission tasks as stated in mission scenario (Reference 2.1a).

e. The extent of integration is essentially as scoped within AFAL's IDAMST study report Vol. II. (reference 2.2g)

   Navigation
   Communication
   Controls and Displays (HUD, HSD, MFD, etc)
   System Status Monitoring

f. Consideration of potential C-14 design as currently implemented in the YC-14 was used to facilitate system definition with respect to physical size constraints, location of hardware, and system design.

In application of assumption d above, it was recognized that certain mission tasks could not be done because of subsequent deletion of avionics equipment from the equipment list without a subsequent update to the mission scenario such as AWRD's. In these situations the tasks was accomplished by alternate techniques or omitted.

## 1.5 PROGRAM APPROACH

Figure 4 illustrates the program task flow directed towards the end result, the specification of IDAMST software. The supporting system analysis was directed specifically towards establishing software requirements. Two separate facets of this phase of program activity were pursued. They were as follows:

1. IDAMST system hardware baseline analysis.
2. Mission operational analysis.

From the system baseline analysis details of the IDAMST hardware/software interface were established that impose software requirements. From the mission operational analysis software requirements were derived to support crew and subsystem functional operation, and operational performance, growth, and mission reliability considerations.

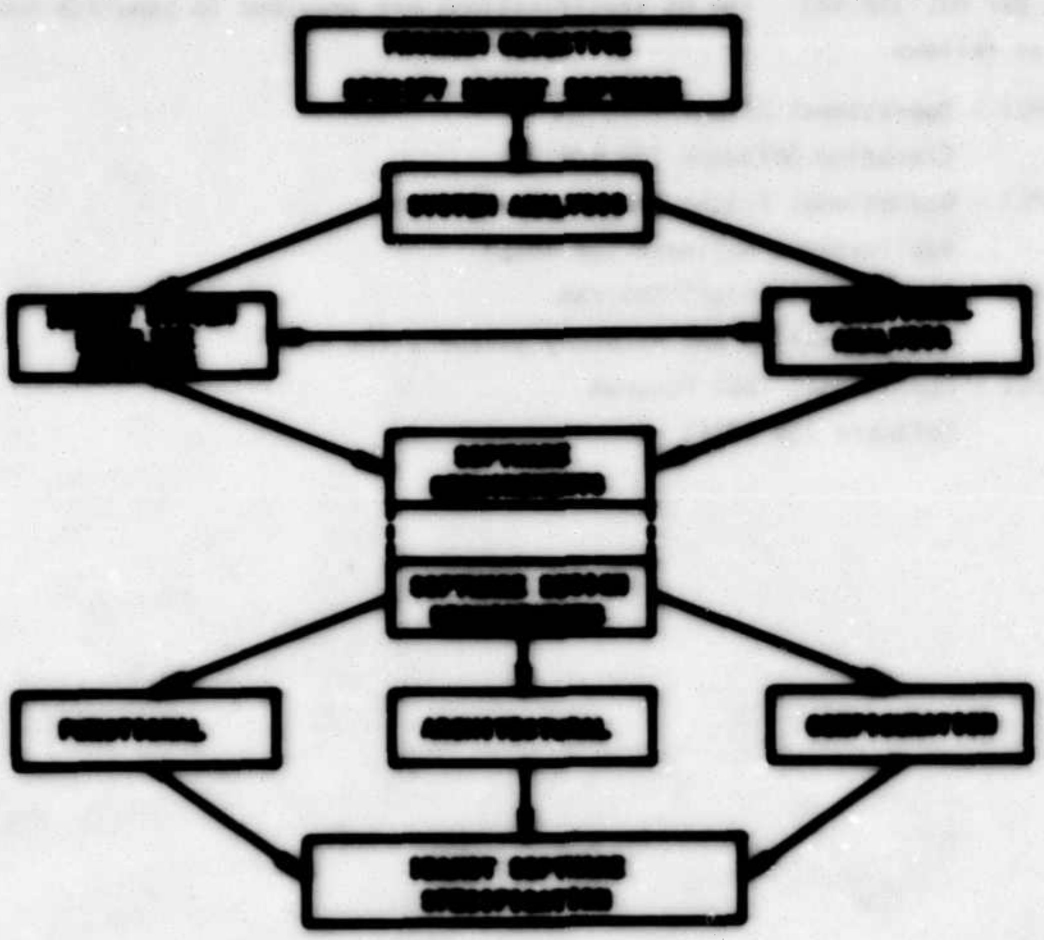



FIGURE 4. PROGRAM TASK FLOW

The software design requirements were subsequently developed from application of the specific IDAMST software requirements to existing DAIS architecture. The resulting IDAMST software design therefore represents the extention of DAIS technology, both hardware and software to the AMST aircraft. The resultant IDAMST software design is systematically defined in terms of functional, architectural and configuration requirements and documented as computer program development specifications type B5 in accordance with MIL-STD-490 as per MIL-STD-483. The B5 specifications are provided in separate documents as follows:

CPCI - Operational Flight Program
Executive Software (SB 4001)

CPCI - Operational Flight Program
Applications Software (SB 4002)

CPCI - Operational Flight Program
Error Handling and Recovery Software (SB 4003)

CPCI - Operational Test Program
Software (SB 4004)

# SECTION II
# APPLICABLE DOCUMENTS

## 2.1 REQUIREMENTS DOCUMENTS

The following documents are applicable as requirements to the SOW activity discussed in this report.

a. Appendix A to SOW - Update - "IDAMST Mission Profile and Scenario".
b. Appendix B to SOW - Update "IDAMST Operational Sequence Diagrams".
c. Appendix C to SOW - "System Architecture".
d. Appendix E to SOW - Update - "DAIS Mission Software, Operational. Flight Program Applications (DAIS-OFP-A (SA-301-300)", Preliminary, 17 Jan. 76.
e. Appendix F to SOW - Update - "DAIS Mission Software Executive. Specification F33615-75-C-1101 (CR-130) SA-301-300)", Preliminary, 26 Dec. 75.
f. Appendix H to SOW - "Software Management Plan".
g. Appendix M to SOW - Update - "TRW System Backup and Recovery Strategy (TRW [illegible])", Sept. 75.

## 2.2 REFERENCE DOCUMENTS

The following documents are applicable as prime reference documents to the SOW activity discussed in this report.

a. Prime Item Development Specification for DAIS Bus Control Interface Unit, Type B1, (SA-301-300B-1S) Preliminary, March 76.
b. Interface Control Document - Mission Operation Sequence: Pilot/ Controls and Displays/Interface with Applications Software (SA [illegible]-300), Preliminary, 15 March 76.
c. Mission Software/Controls and Displays Interface (SA [illegible]-301), Preliminary, 12 March 76.
d. Controls and Display Electronics for IDAMST, Draft copy.
e. IDAMST Signal List (SCI), Preliminary.
f. DAIS System Control Procedure (SA 100-101 Appendix A), 7 Nov. 75.
g. Integrated Digital Avionics for a Medium STOL Transport, Volume II. (No document number), March 75.

## 2.3 [illegible] REFERENCE DOCUMENTS

The following documents are considered prime reference documents to definition of the [illegible] system but because of release schedules were not available under the noted documented cover during the course of this program. Much of the specific information however is stated in the previously referenced documents of Paragraphs 2.1 and 2.2.

a. System Specification for [illegible] - Type A (SI-1000) dated June 1976.
b. System Specification for [illegible] - Information Transfer System - Type A (SS-3000) dated May 1976.
c. Prime Item Development Specification for [illegible] Remote Terminal - Type B1 (SS-3120) dated May 1976.
d. Prime Item Development Specification for [illegible] Bus Control Interface Unit - Type B1 dated May 1976.
e. Prime Item Development Specification for [illegible] Processor - Type B1 (SI-4000) dated June 1976.
f. System Segment Specification for [illegible] Control/Display Subsystem - Type A (SI-6000) dated June 1976.

# SECTION III
# SYSTEMS ANALYSIS

The systems analysis task as indicated in Figure 4 was divided into two distinct areas of investigation. The IDAMST system hardware baseline analysis and the mission/operational analysis. The results of this investigation into the IDAMST hardware characteristics and mission operations has provided the following:

a. A detailed definition of hardware/software interfaces.

b. Definition of an integrated navigation system.

c. IDAMST operational requirements.

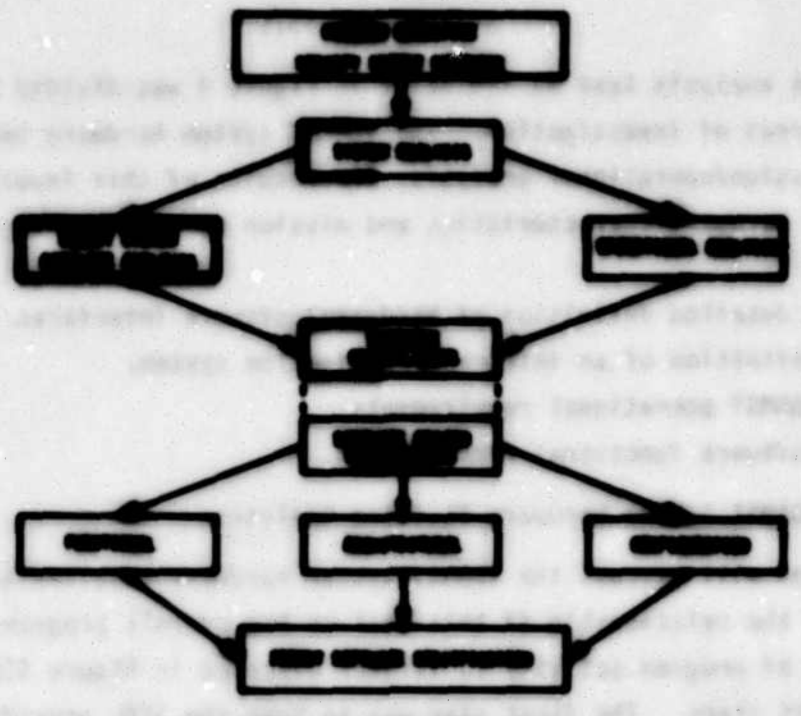
d. Software functional requirements.

## 3.1 IDAMST System Hardware Baseline Analysis

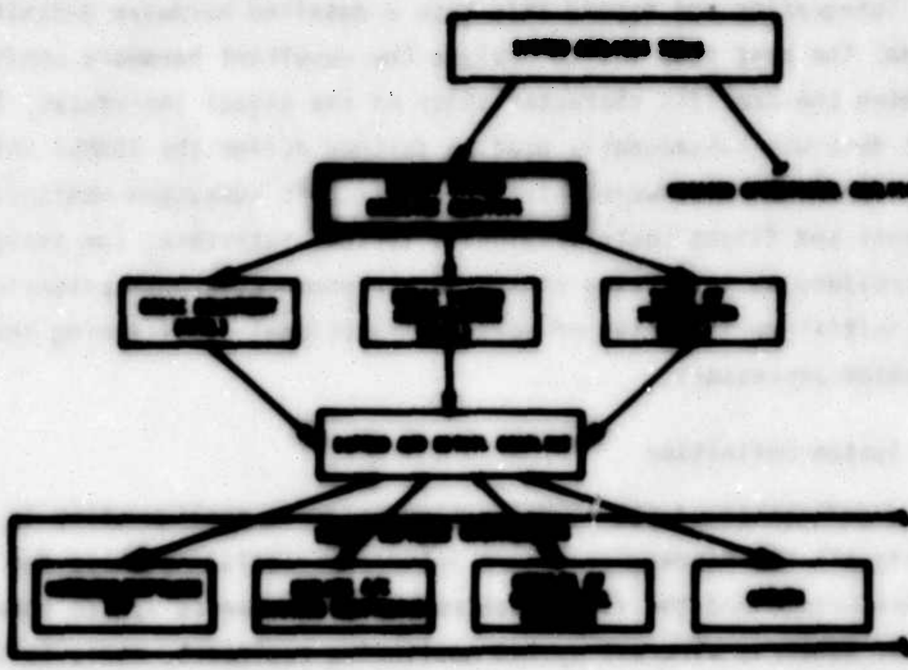
This section will discuss the IDAMST system hardware baseline analysis. Figure 5(a) shows the relationship of this task to the overall program activity. This phase of program activity is further expanded in Figure 5(b) to show two distinct steps. The first step was to take the AFAL provided system definition in terms of a basic equipment list, the system architecture and the scope of integration and expand this into a detailed hardware definition of the system. The next step was to analyze the resultant hardware configuration to determine the specific characteristics of the signal interfaces. The resultant data was subsequently used to further define the IDAMST software in terms of hardware/software interfaces, aircraft subsystem monitoring requirements and flight control/avionics systems interface. The analysis further provided an indication of system performance, growth potential and provided initial verification of software functional partitioning between the three mission processors.

### 3.1.1 System Definition

A detailed definition of the IDAMST system hardware configuration is required to identify all the hardware/software interfaces including those for aircraft system monitoring, and the flight control system/avionics system interface. The avionic sensors, aircraft system monitoring equipment, etc., is integrated into the IDAMST system and forms an overall architecture that is similar to the basic design of the Digital Avionics Information System (DAIS) design. For IDAMST the system physically consists of the following quantity and types of line-replaceable units (LRU's).



(a) [illegible] PROGRAM TASK FLOW



(b) SYSTEM BASELINE ANALYSIS TASK FLOW

FIGURE 5. [illegible] SYSTEM BASELINE ANALYSIS

| | |
|---|---|
| Avionic Sensors | 221 LRU's |
| Controls and Display | 61 LRU's |
| [illegible] Integration Elements | 14 LRU's |

A block diagram of the [illegible] system showing the interconnection of the 296 LRU's is provided by Figure 6. The avionic sensors are functionally partitioned into the following six types:

a. Instrument and Aircraft Systems.
b. Navigation Systems.
c. Communication and Identification Systems.
d. Radio Aids to Navigation Systems.
e. Defensive Countermeasures Systems.
f. Payload Systems.

Table 1 defines the subsystems associated with each of these categories. The controls and displays involved in the [illegible] system consist of the pilot, copilot, center console/aisle stand, and pilot/copilot side panels. These crew interfaces represent the areas within the flight deck that are associate with mission avionics and aircraft performance monitoring. Not included in [illegible] are the dedicated flight control system panel located on the glare shield and the airframe dependent subsystem located in the overhead. Figure 7 shows the pictorial layout of the flight deck while Figure 8 shows the hardware interconnects. A close-up of the forward aisle stand, with accessory panels, is shown in Figure 9. The basic concept associated with the controls and displays is to provide an integrated crew interface with the avionics while maintaining the conventional pilot-copilot separation which is evident in transport vehicles. The [illegible] integration hardware consists of three mission processors with associated bus control interface units, eleven remote terminals, and a dual redundant MIL-STD-1553 data communication network.

The physical layout of the [illegible] system as applied to the Boeing C-14 airplane is shown in Figures 10 and 11. The four integration areas are:

a. nose wheel avionics bay.
b. cargo avionics bay.
c. flight deck avionics bay.
d. flight deck panel area.

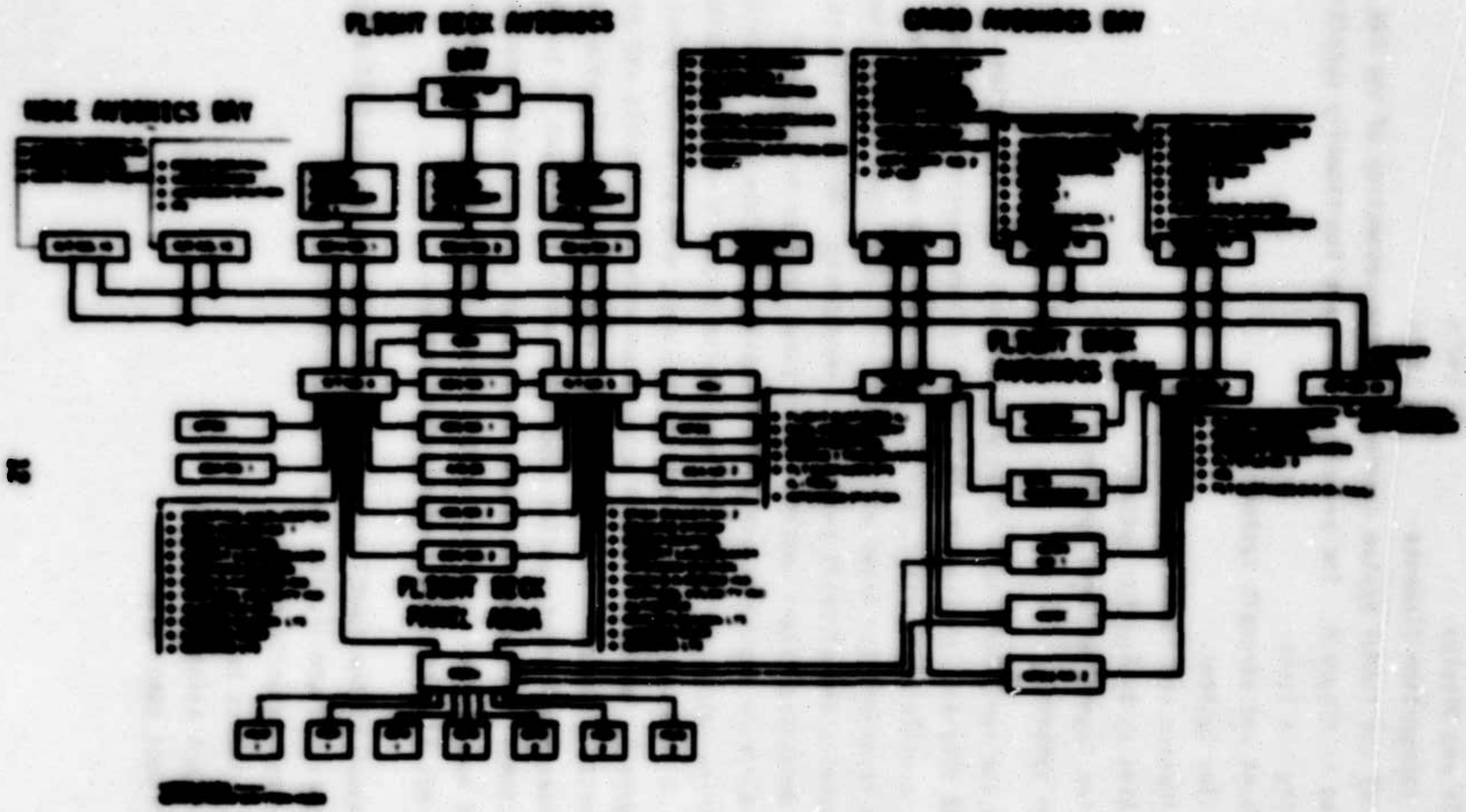



FIGURE 6. IDAMST SYSTEM BLOCK DIAGRAM

## INSTRUMENT & AIRCRAFT SYSTEMS

### AVIONICS

### CONTROLS & DISPLAYS

### CONTROLS & DISPLAYS

## NAVIGATION SYSTEMS

### AVIONICS

### CONTROLS & DISPLAYS

TABLE 1 [illegible] HARDWARE DISPOSITION

... SYSTEMS

## COMMUNICATION SYSTEMS

### AVIONICS

### CONTROLS & DISPLAYS

## RADIO AIDS TO NAVIGATION

### AVIONICS

### CONTROLS & DISPLAYS

... & DISPLAYS

## ELECTRONIC COUNTERMEASURES SYSTEMS

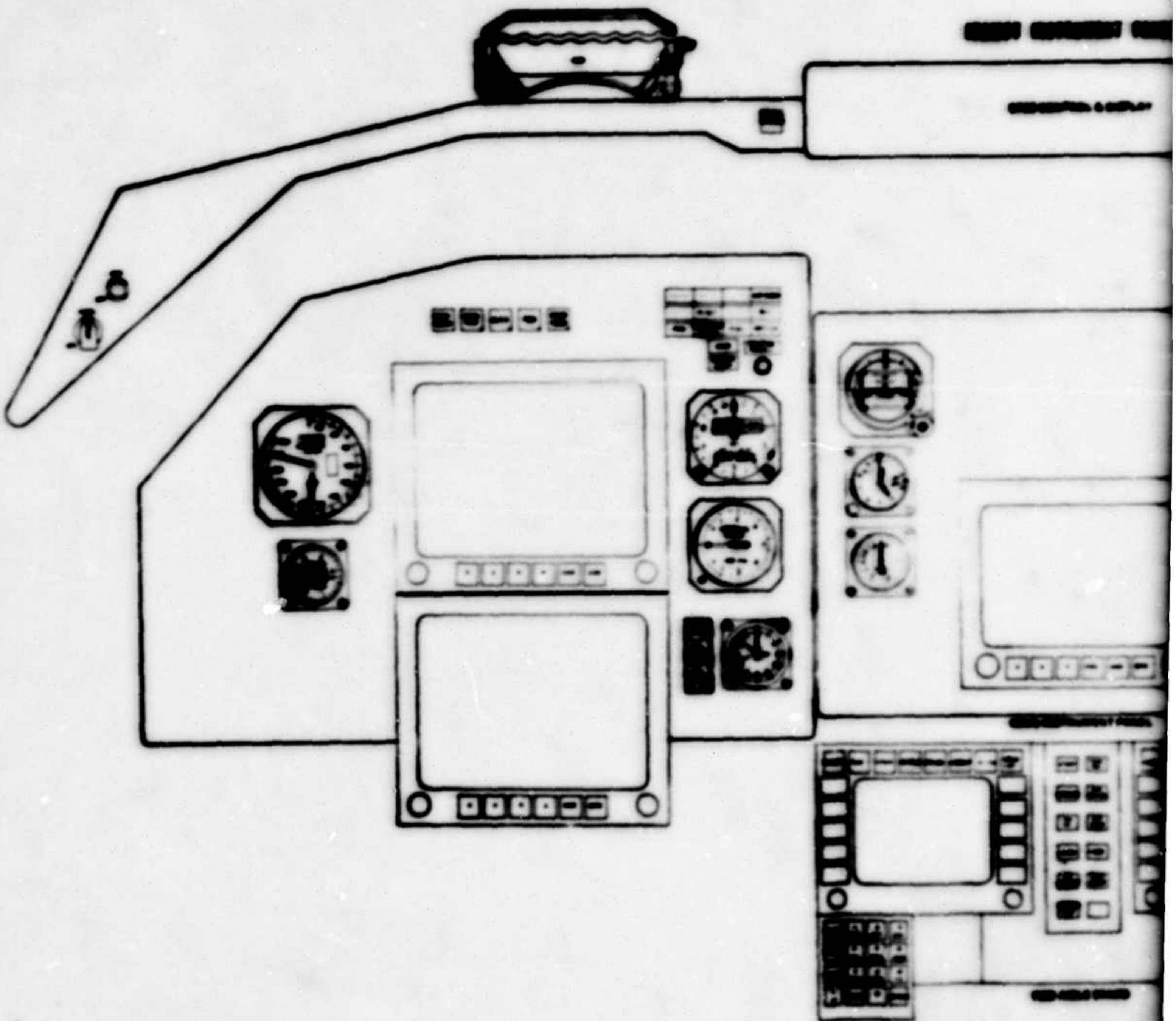
### AVIONICS

### CONTROLS & DISPLAYS

## PAYLOAD SYSTEMS

### AVIONICS

### CONTROL & DISPLAYS



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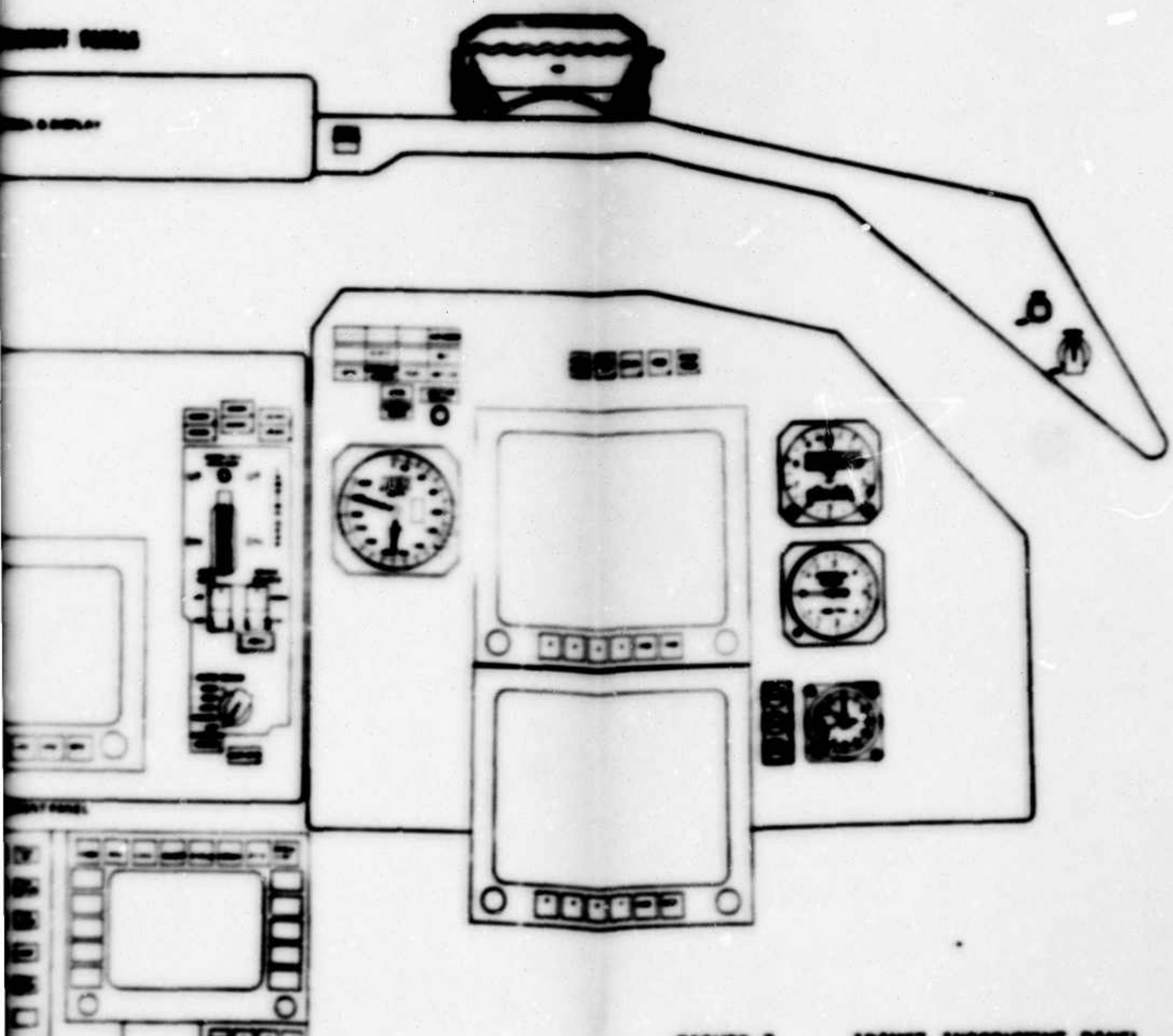


FIGURE 7. IDAMST INSTRUMENT PANEL



2

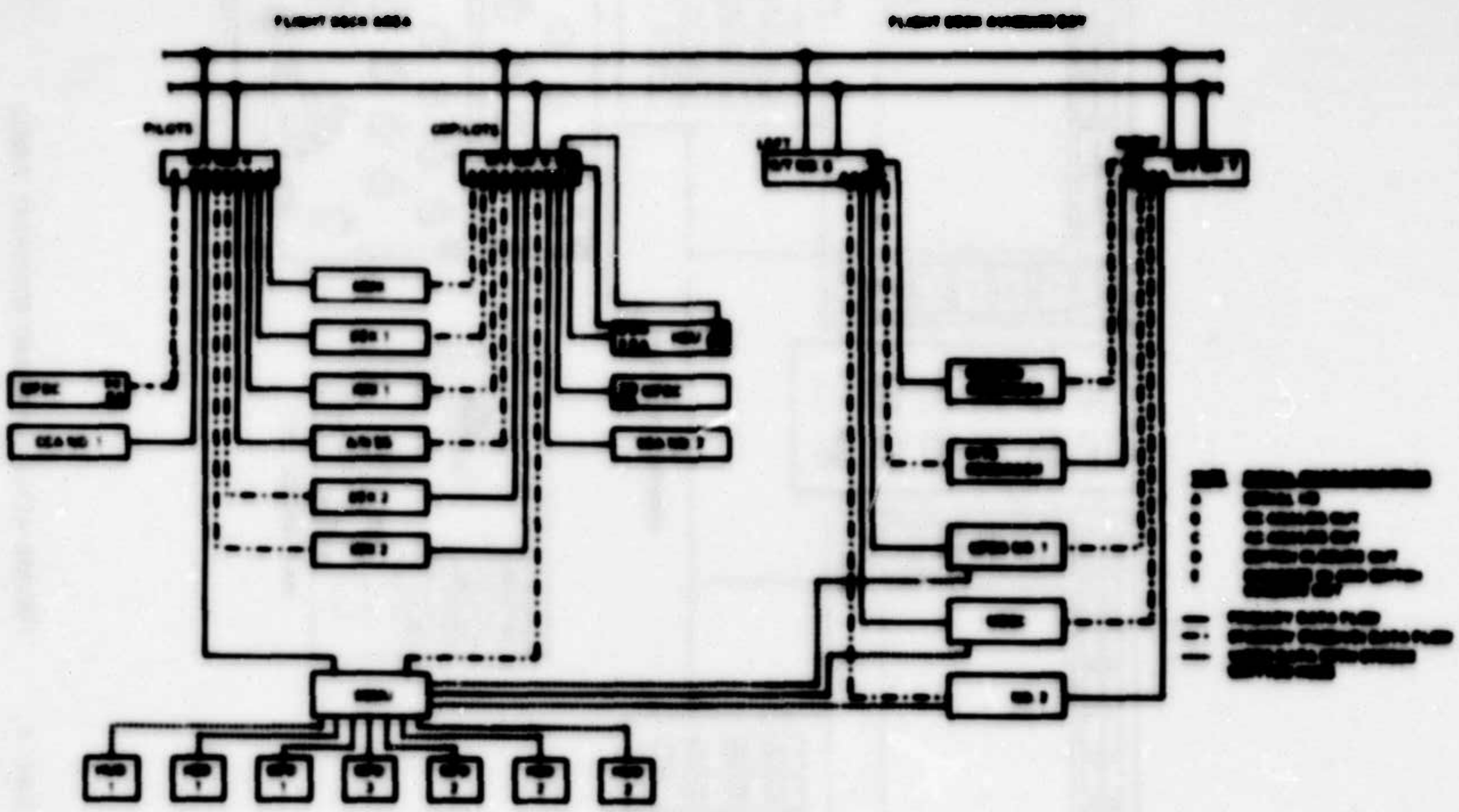


FIGURE 8. FLIGHT DECK EQUIPMENT INTERCONNECT

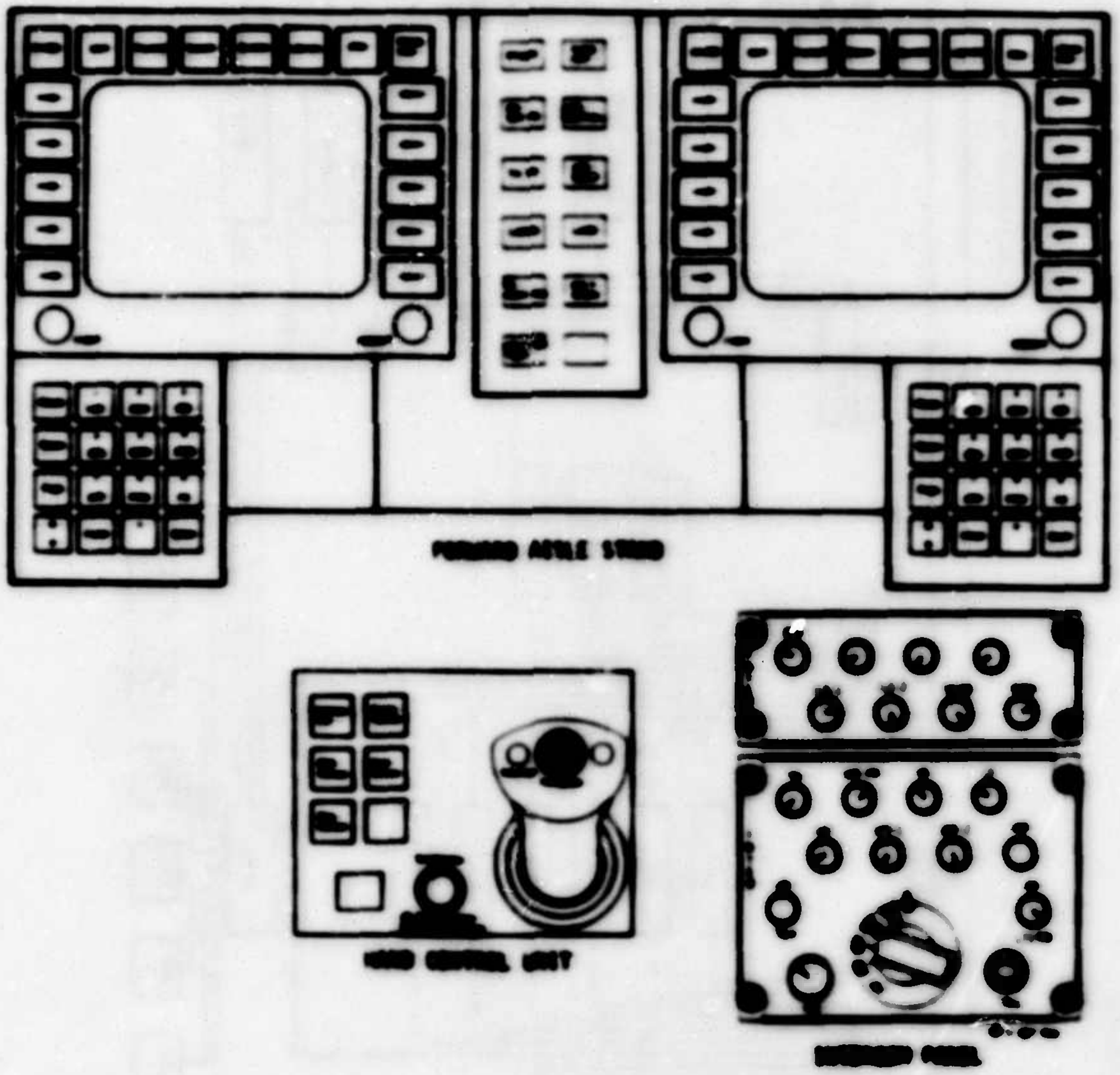



FIGURE 9. FORWARD AISLE STAND AND ACCESSORY PANELS

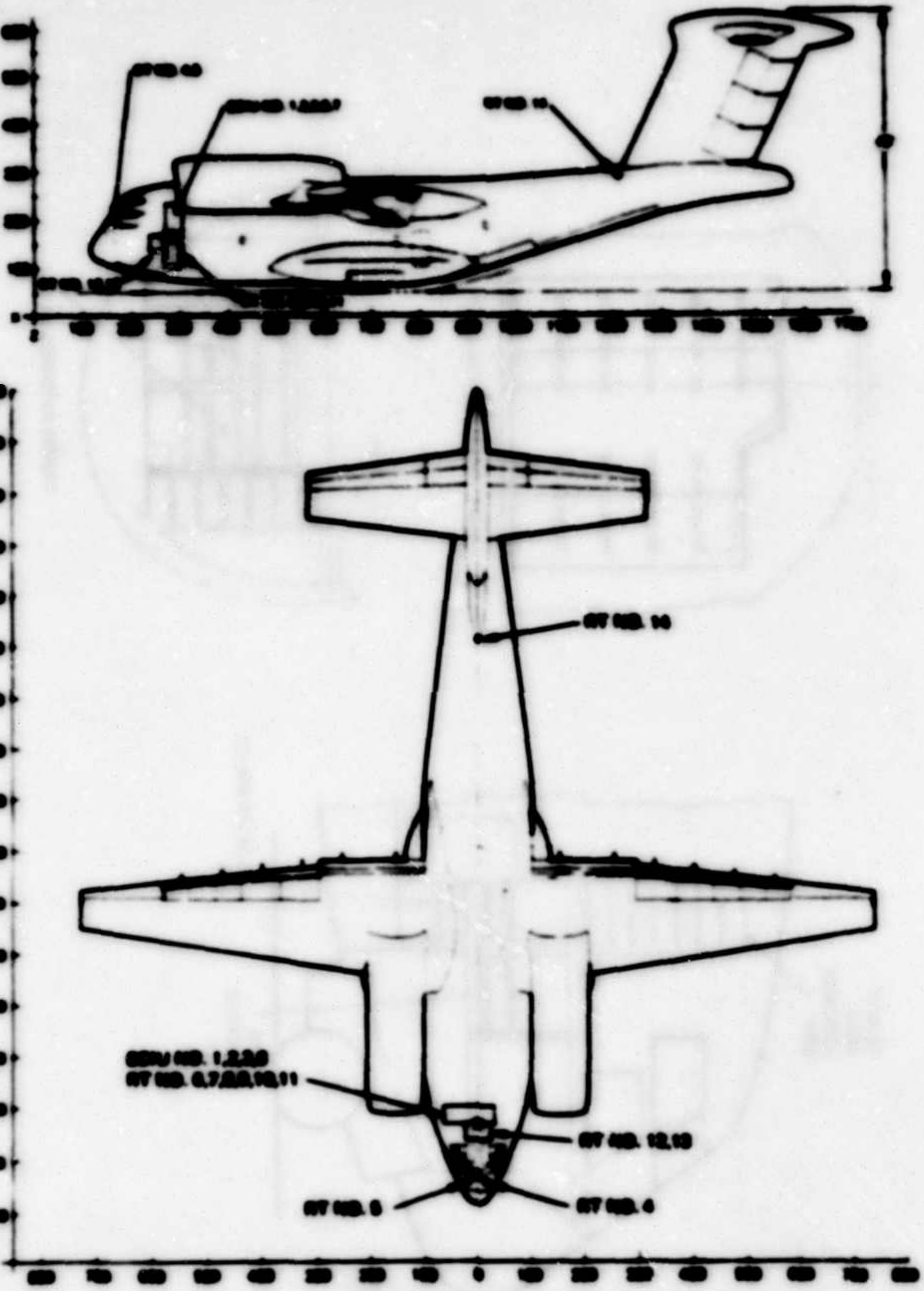


FIGURE 10. [illegible] SYSTEM LAYOUT IN C-14

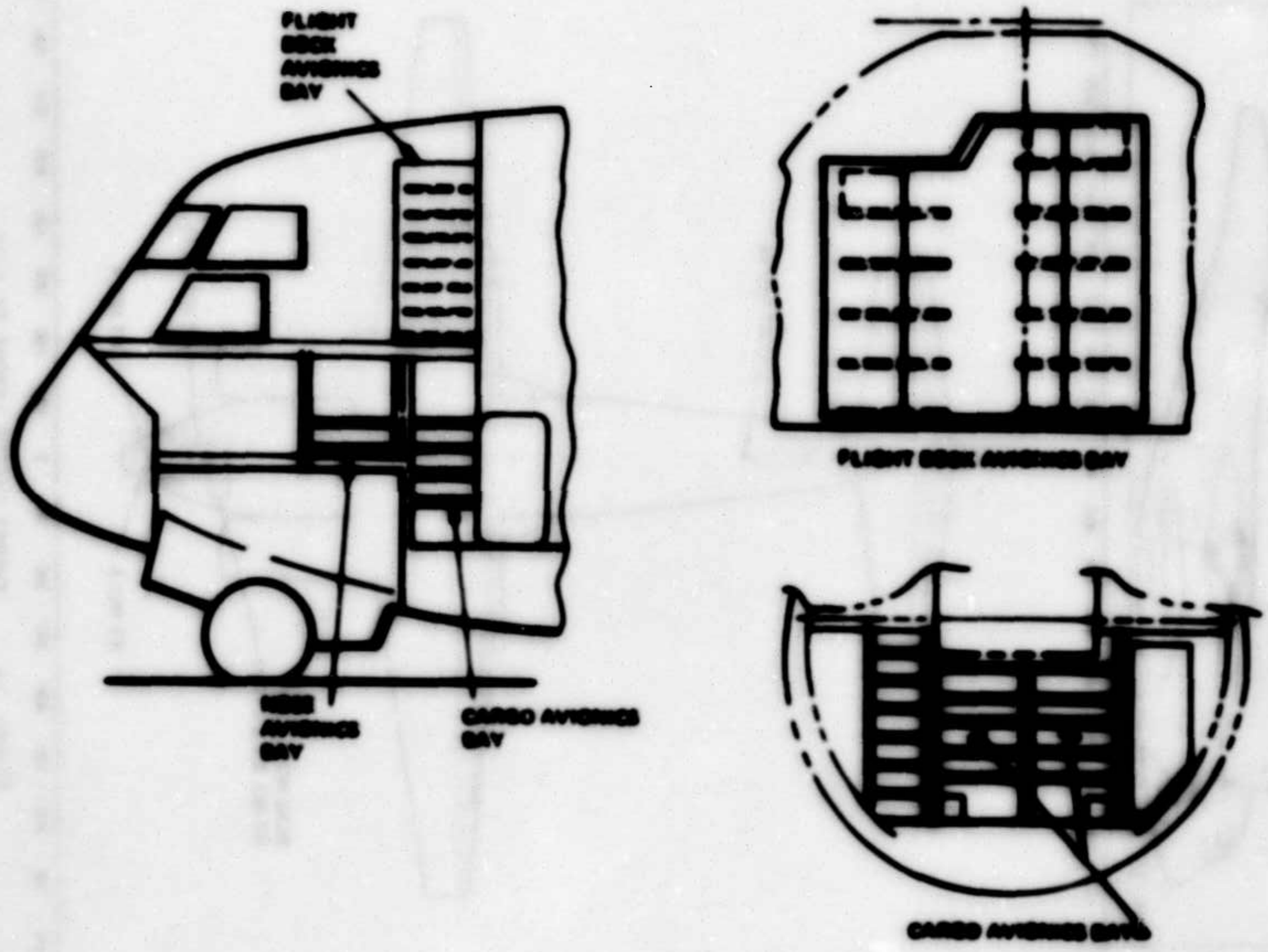



FIGURE 11. C-14 AVIONICS BAYS

Location of the avionics equipment in relation to the above areas provides separation of redundant functions while providing conventional locations of equipment associated with transport vehicles. System integration is provided by the IDAMST architecture which uses the data communication network and the mission software partitioning to achieve the IDAMST functions.

The IDAMST system design was established using the following architectural ground rules.

a. Subsystems interface to IDAMST only when there are processing, displays, or geographical data transfers requirements.

b. Subsystems interface to IDAMST through standard interfaces.

c. The communication network is a military standard data bus.

d. Processors are military standard units.

e. Special flight control interface requirement.

f. Control of its own electrical power.

g. Growth capability.

The IDAMST system design and architecture can best be described as a distributed processing system using standard interfaces, standard communication methods, general purpose military qualified processors, and existing avionic sensors. The advantage of such a system is to produce commonality of integration techniques and hardware for many vehicles regardless of integration needs. This allows standard hardware developments, reuseable software modules, and common system engineering. To extend these methods to IDAMST, the DAIS core element hardware and software architecture was used as a base with adaptions to satisfy the unique requirements of the AMST.

The operation of the IDAMST system is maintained by the master, monitor, and remote processors. Functionally the master processor has been assigned the pilot functions as well as the system executive activities. The monitor processor, likewise, has been assigned the copilot functions and also performs the monitor executive functions in case of master failure. The remote processor is assigned the aircraft monitor and control functions. Each of the processors interface with the communication network via a bus control interface unit (BCIU). The master processor and its associated BCIU has been assigned prime bus control. The bus communication is a command/response

format. The master BCIU commands all bus communications to be received and directs all transmitted messages to itself, other BCIU's, or remote terminals. In this way, data is distributed for processing, display, or control. The data system operates synchronously by time sequenced addressing each signal associated with each LRU. The maximum signal address rate is 64 times a second (a minor frame) while the minimum is once a second (major frame). The addressing of signals is under the control of the master processor via the master BCIU and the remote terminal associated with a given LRU. Individual LRU's are addressed at a rate based on each signal's refresh requirement, therefore, an LRU may be interfaced with its associated data source or destination several times within a minor frame. Remote terminals interface with the communication system on one side and the LRU signals on the other. Both these interfaces are standard and may operate asynchronous or synchronous to each other depending on the hardware mechanization. Separation of avionic sensors are maintained within IDAMST by similar and dissimilar redundancy. Similar redundancy provides two or three units of identical quality interfaced to different remote terminals and processed in separate mission processors with the calculated results compared. Dissimilar redundancy occurs when functional capability is obtained from two or three different hardware items. In most cases, these are also interfaced and processed in separate remote terminals and mission processors and the results compared. In this way, avionics separation by functional partitioning is maintained. In a somewhat different way, redundancy and separation is provided in the controls and displays area. The pilot-copilot functions are separated both functionally and physically. Figure 8 shows that four remote terminals are used to interface the crew controls and displays with the IDAMST system. Notice that the controls are displays are located in two geographical locations: Flight deck panel area and flight deck avionics bay. These locations were chosen to limit the behind the panel requirements in the flight deck and to install as much of the avionics hardware in the controlled bay areas. Therefore, separation of pilot-copilot functions requires the use of two remote terminals per area. It should be noted that the remote terminals in the flight deck avionics bay also interface with other sensors. To obtain maximum flexibility under several failure conditions, all of the crew controls and displays were interfaced to both remote terminals. This hardwired redundant interface produces within each

LRU a prime and passive backup interface to the IDAMST system, thus, allowing several failures before loss of pilot or copilot functions.

The AMST flight control system model used for this study was essentially the same as currently used in the YC-14 prototype aircraft. This aircraft features a triple redundant electronic flight control system (EFCS) utilizing three digital processors. As part of the assumed design for this study the flight control system requires air data and attitude reference information for normal operation. Since this information is also required for flight display an interface to the EFCS system is proposed. This interface is shown by Figure 12 and requires one remote terminal interface for each EFCS channel. In addition to the air data values and attitude information, EFCS status is received from and steering signals transmitted to the flight control system. Table 2 list the specific interface signals.

Control of the EFCS is still integral to itself with steering data available on an "as selected" basis.

### 3.1.2 IDAMST System Analysis

An analysis of the IDAMST system shown in Figure 6 was conducted to provide a detailed list of signals between the various LRU's and the mission processors, the performance of resultant baseline design and growth potential. The primary analytical tool used to facilitate the analysis was MUXSIM. MUXSIM is a computer based data network analysis aid developed under the sponsorship of AFAL by the Harris Corporation (contract number F33615-73-C-1172). The MUXSIM data base contains detailed characteristics of LRU signals. This data base was updated for this program to reflect the specific equipment list used. An example of the signal list is given in Table 3. The complete list is incorporated into the IDAMST Computer Program Development Specification for the Applications Software (SD-4842) and serves as a portion of the definition of the hardware/software interface.

MUXSIM also provided the basic information for evaluating system performance and growth capability of the baseline design. Three iterations of the design were performed and supported by MUXSIM to allow evaluation of the

TABLE 2 AVIONICS/FLIGHT CONTROL SIGNALS

| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
|---|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | |
| [illegible] | [illegible] | | | [illegible] | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | |

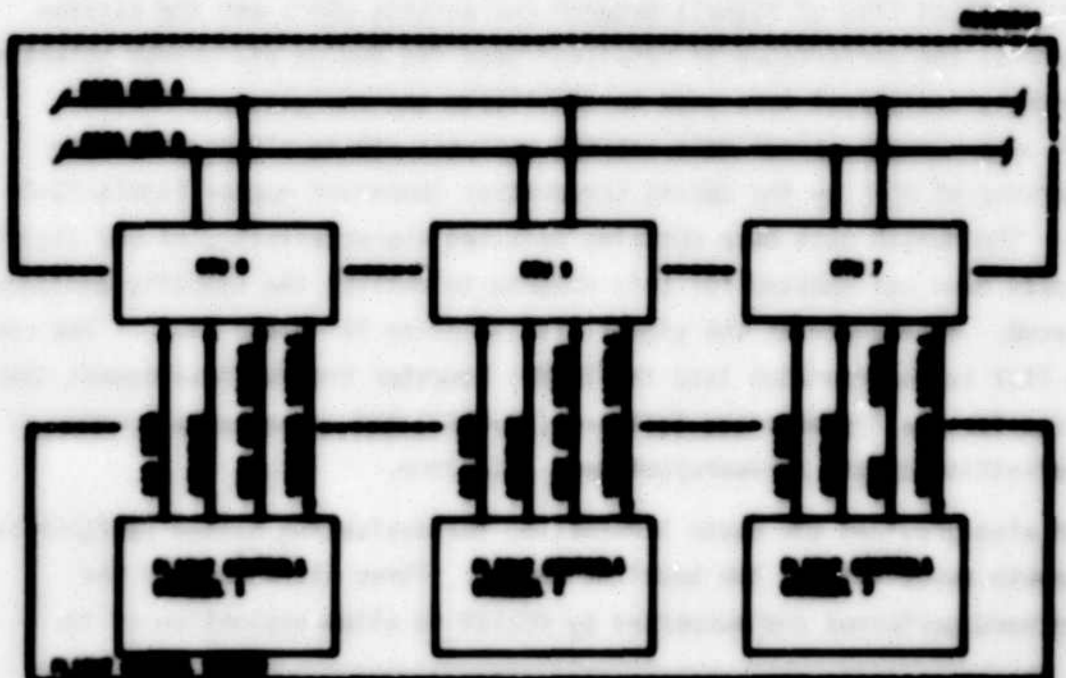


FIGURE 12. AVIONICS/FLIGHT CONTROL SYSTEM INTERFACE

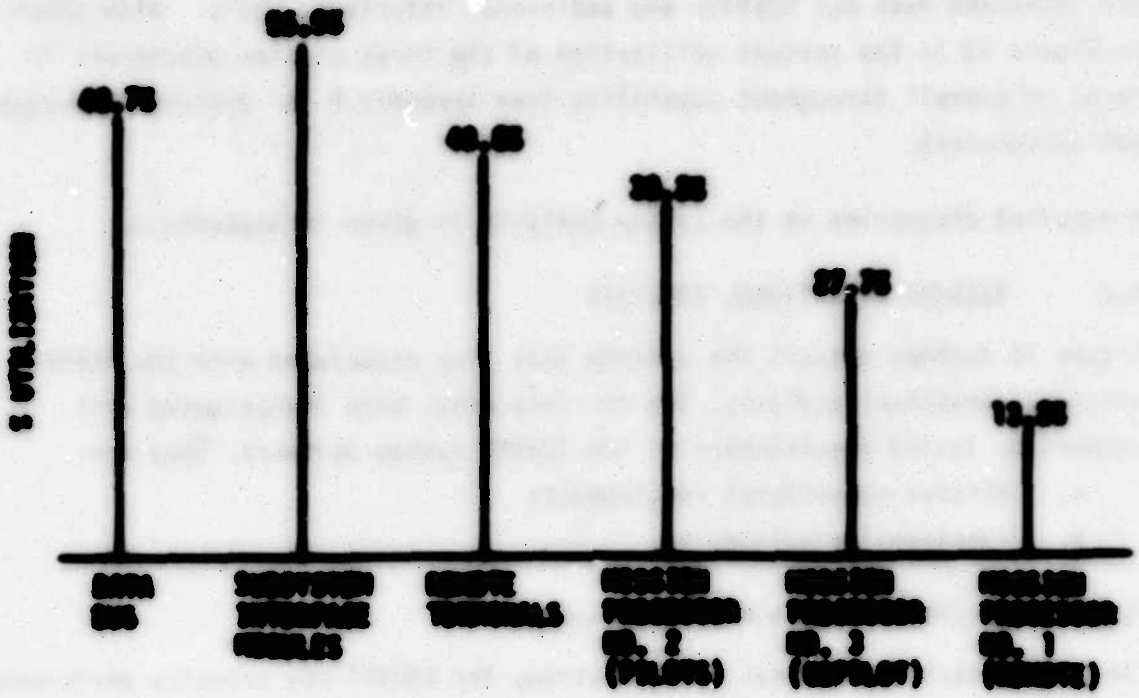



FIGURE 13. IDAMST SYSTEM UTILIZATION

TABLE 3 IDAMST SIGNAL LIST OF APPLICATIONS SOFTWARE (EXAMPLE)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | | | | | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | | [illegible] | | | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | | [illegible] | | | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | | [illegible] | | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | | | | | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

effects of various software partitioning schemes, methods of data transmission, and the impact of growth items on system performance. Figure 13 summarizes the results of the final analysis performed in terms of percent of utilized system capability. As can be seen, considerable growth capability exists for increased data bus traffic and additional interfaced LRU's. Also shown in Figure 13 is the percent utilization of the three mission processors in terms of overall throughput capability (see Appendix B for processor throughput discussion).

A detailed discussion on the system analysis is given in Appendix A.

## 3.2 MISSION OPERATIONAL ANALYSIS

Figure 14 further details the program task flow associated with the IDAMST mission/operational analysis. Two distinct areas were investigated with respect to levied requirements on the IDAMST system software. They are:

a. Mission operational requirements.

b. Functional requirements.

### 3.2.1 Mission Operational Requirements

The fundamental operational considerations for IDAMST are avionics performance, future requirements, and mission reliability. These items were assessed with the objective of defining specific software requirements for IDAMST. The key AMST operational requirements affecting the IDAMST design are as follows:

a. Performance - 100 meter CEP for CARP.

b. Future - GPS, JTIDS, TA/TF and Area Nav.

c. Mission Reliability - Maintain Mission Essential Capability.

#### 3.2.1.1 Performance

It has been assumed that a 100 meter CEP for CARP is an AMST operational objective and a requirement for this study. Table 4 summarizes performance capabilities of various CARP mechanization schemes.

TABLE 4

ESTIMATED CARP OPERATIONAL PERFORMANCE CAPABILITIES

| Scheme | Performance |
|---|---|
| SKE/ZM/INS* | 100 meters |
| GPS/INS | 30 meters |

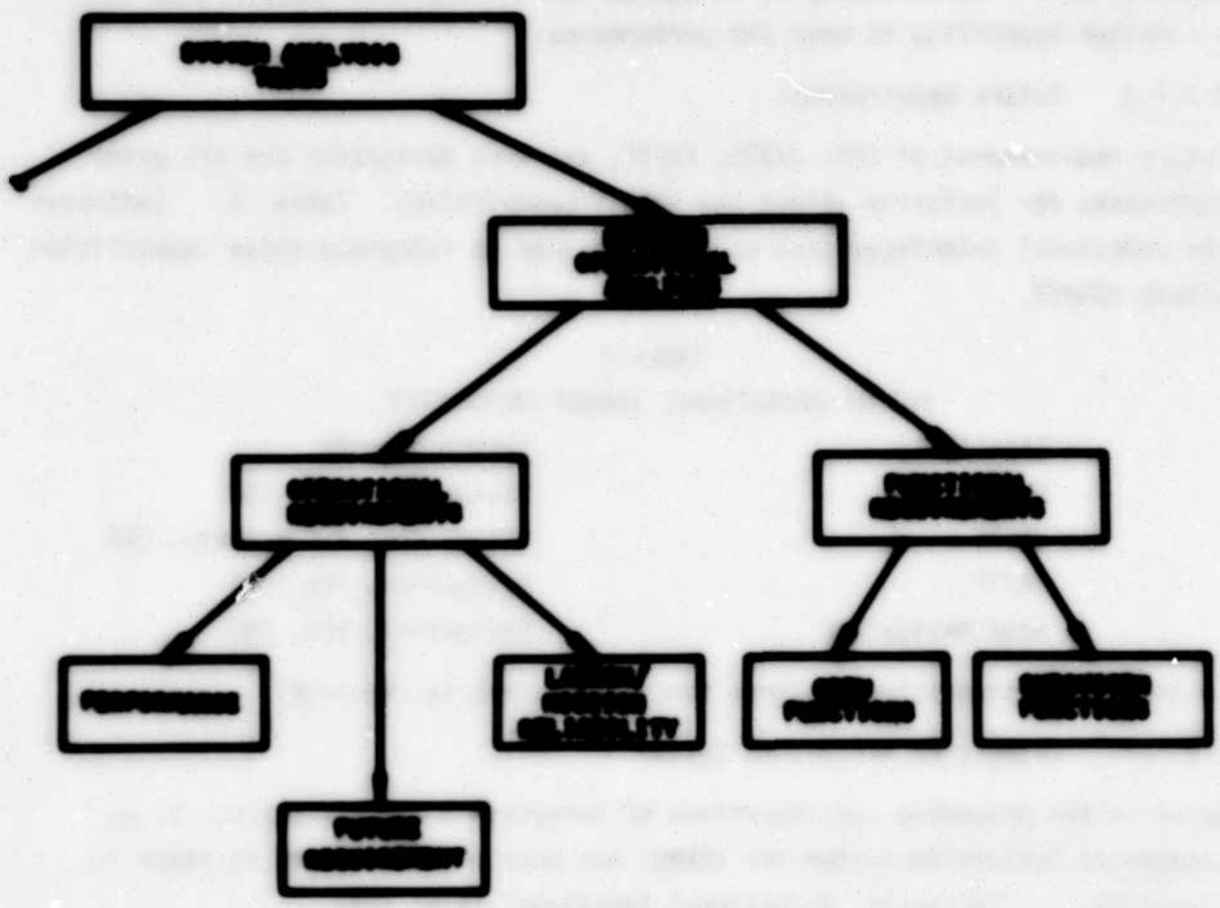


FIGURE 14. MISSION/OPERATIONAL ANALYSIS TASK FLOW

| Scheme | Performance |
|---|---|
| GPS/Doppler/AHRS | 60 meters |
| Precision Map/INS/Doppler/AHRS | 100 meters |
| Omega/INS | 300-1000 meters |

*assumes auto steering

Within the immediate future and considering cost, the SKE/ZM/INS approach is the most likely candidate for achieving 100 meter CEP. The GPS/INS mechanization, however, will be realizable in the 1982 and on time span and therefore is a prime growth consideration. In either case the significance of the requirement is the necessity to integrate several separate capabilities into a combined capability to meet the performance.

3.2.1.2 Future Requirements

Future requirements of GPS, JTIDS, TA/TF, and Area Navigation are all prime candidates for inclusion within the IDAMST capabilities. Table 5 indicates the functional interfaces that will be required to integrate these capabilities within IDAMST.

TABLE 5

FUTURE OPERATIONAL IDAMST INTERFACES

| Capability | Interface with |
|---|---|
| GPS | Navigation, FCS, C&D |
| JTIDS | Navigation, A/C systems, C&D |
| TA/TF | Navigation, FCS, C&D |
| Area Navigation | Navigation, FCS, C&D |

In each case integration of three functional areas is required.

3.2.1.3 Integrated Navigation System

Based on the preceding considerations of Paragraph 3.2.1.1 and 3.2.1.2, an integrated Navigation system for IDAMST has been postulated and is shown in Figure 15. The basic navigational functional tasks are:

a. Management of the Navigation system (Functions).
b. Processing of Navigation data.
c. Display of Navigation information.
d. Steering signals to Flight and Propulsion systems.

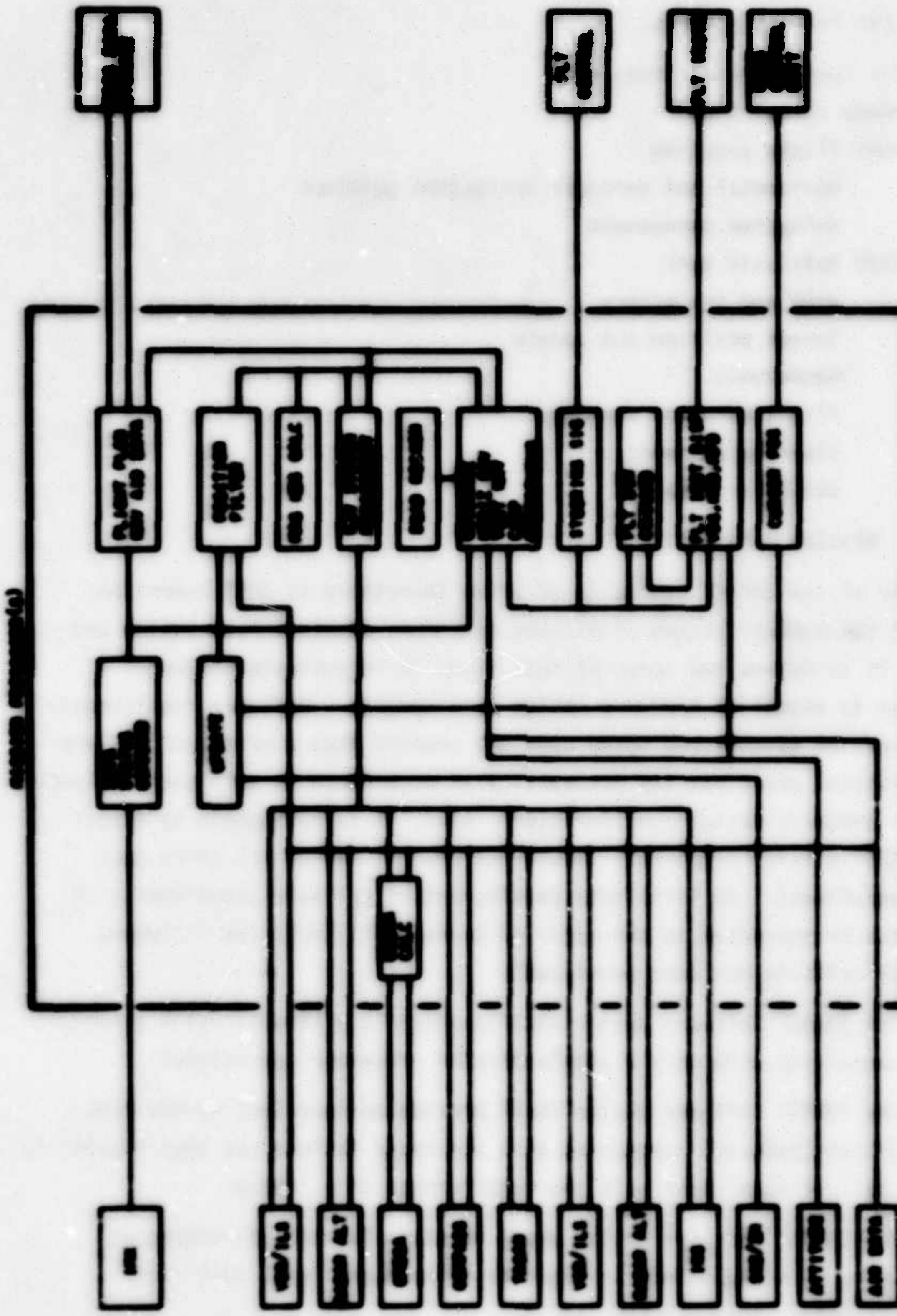


FIGURE 15. INTEGRATED NAVIGATION SYSTEM

e. CARP release signals.

The specific computational tasks are:

a. Omega calculations

b. RNAV Flight planning

Horizontal and vertical navigation guidance

Subsystem management

c. CARP Ballistic data

Wind and trajectory

Target position and update

Rendezvous

Flight director commands

Steering commands

Ballistic data

### 3.2.1.4 Mission Reliability

Reliability of the IDAMST system is of prime importance to AMST operation because of the centralization of mission functions within three mission processors. It is beyond the scope of this study to investigate hardware reliability to establish hardware design requirements. Software requirements can, however, be established based upon the premise that a processor failure is a statistical event and the probability of occurrence is sufficiently large to warrant software design consideration. Also, it is reasonable to expect that the AMST mission capability should not rest on having all three processors operational. To facilitate development of software requirements to support mission operation in the event of hardware failures the following operational criteria has been developed.

a. The IDAMST Software design shall maintain a minimum mission essential capability with only a single mission processor operational.

b. The IDAMST Software design shall provide an invariant system capability (reduced) subsequent to a processor failure and that capability shall be consistent with the requirements of a. above.

c. The IDAMST Software design shall maintain functional redundancy where such redundancy is inherent in hardware (e.g. dual radar altimeter, dual ILS/VOR, etc.).

### 3.2.1.4.1 Minimum Mission Essential Capability

Air Force studies and the MAC ROC have been reviewed with respect to the minimum mission essential capability for the AMST. Figure 16 tabulates the established minimum mission function versus the various basic AMST missions. Each mission function indicated requires IDAMST software support. Table 6 summarizes the minimum mission capability including flight safety. Consistent with the above stated criteria (Paragraph 3.2.1.4.a) this capability shall be maintained with only a single mission processor operational. The stated functions in Table 6 have been expanded slightly (noted by asterisk) over the identified mission functions of Figure 16 to include an indication of avionics equipment status, display of control surfaces, and display of engine parameters.

TABLE 6
MINIMUM MISSION ESSENTIAL CAPABILITY

<u>Minimum Mission Fuctions</u>

- Flight Safety
- INS
- Omega
- SKE/ZM
- Defense
- ADF
- Radar
- CARP

<u>Flight Safety Functions</u>

- Communications - Control/Display
  - Display of:
    - Air data (alt, airspeed, etc.)
    - Attitude
    - Heading
    - Rate of turn
    - Radar altitude
- ILS/VOR (control/display)
- Ground proximity warning

| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FLIGHT SAFETY | ● | ● | ● | ● | ● | ● | | | | | | | | |
| DEPLOYMENT | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | ● |
| CTL. [illegible] | ● | ● | ● | ● | ● | ● | ● | ● | | ● | | | | ● |
| [illegible] | ● | ● | ● | ● | ● | ● | ● | ● | | | | | ● | |
| [illegible] | ● | ● | ● | ● | ● | ● | ● | ● | | | | | ● | |
| [illegible] | ● | ● | ● | ● | ● | ● | ● | ● | | | | ● | ● | ● |
| CTL. [illegible] | ● | ● | ● | ● | ● | ● | ● | ● | | ● | | | | ● |

*[illegible]

FIGURE 16. [illegible]

TABLE 6 (Continued)

Avionics equipment status*

Control surface display*

Engine parameter display*

* Additional functions not identified in Figure 16.

3.2.1.4.2 System Reconfiguration

Requirement b of Paragraph 3.2.1.4 specifies that upon failure of a mission processor the resultant mission capability shall be independent of which processer failed. The rationale behind this requirement is simply to maintain an invariant interface between the crew and the IDAMST system. If it is assumed that loss of a processer will result in some loss of mission capability potentially the resultant IDAMST capability could be processor dependent and the crew man machine interface would be effected accordingly. In specific terms of software the levied requirement calls for the IDAMST system to reconfigure itself to a known configuration of no less capability than that defined by Table 6, subsequent to failure of one or two processors.

Table 7 provides a schedule for reconfiguration for the AMST for a three, two and one processor hardware configuration.

TABLE 7

IDAMST CONFIGURATION/RECONFIGURATION SCHEDULE

| PROCESSOR STATUS AT LAUNCH | PROCESSOR STATUS DURING MISSION | SOFTWARE CONFIGURATION |
|---|---|---|
| 3 | 3 | 3 processor configuration (full IDAMST capability). |
| 3 | 2 | Upon failure reconfigure<br>o step 1 (auto)*<br>o step 2 (crew enable)* |
| 2 | 2 | Launch with 2 processor configuration |
| 2 | 1 | Upon failure reconfigure<br>o step 1 (auto)* |
| 1 | (No Mission Launch) | |

TABLE 7 (Continued)

| PROCESSOR STATUS AT LAUNCH | PROCESSOR STATUS DURING MISSION | SOFTWARE CONFIGURATION |
|---|---|---|
| | | • Step 1 - Auto reconfigure to Minimum Mission Essential Capability - 1 processor active.<br>Step 2 - Pilot enabled reconfiguration to a 2 processor capability. |

3.2.1.4.3 Functional Redundancy

The IDAMST system is to maintain functional redundancy of hardware were such hardware is specifically provided to increase avionics system reliability. IDAMST software design should not detract from this objective. Similarly the IDAMST software shall maintain the traditional functional separation of redundant displays to pilot and copilot in transport aircraft. Figure 17 illustrates this philosophy for the AMST flight safety functions. In the case of the flight control system (FCS) inputs a signal selection process is used to select the best signals for pilot and copilot display. Simple functional separation will result upon failure of one Flight Control System (FCS) channel.

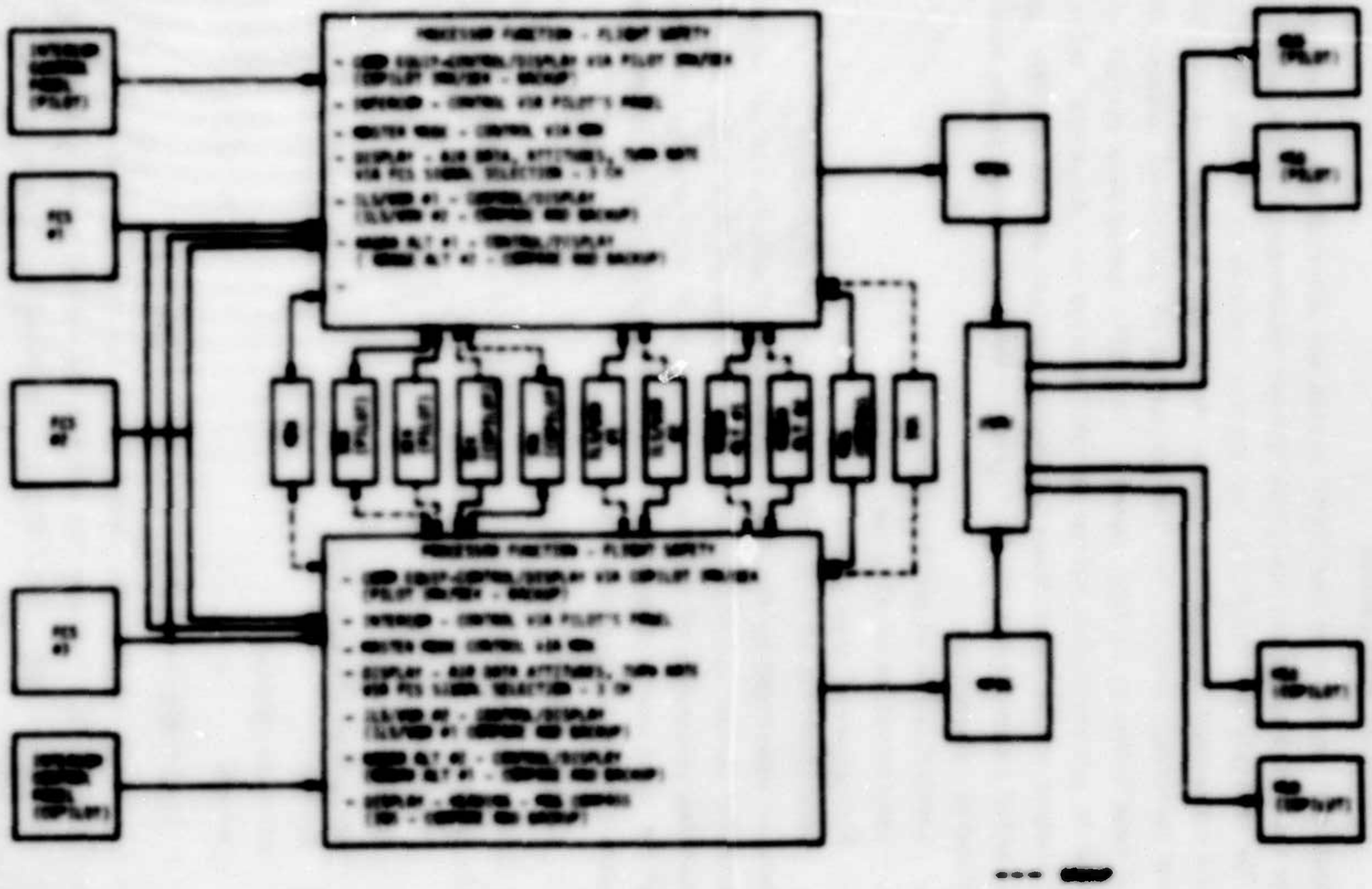


FIGURE 17. FLIGHT SAFETY CONFIGURATION REQUIREMENTS

### 3.2.2 Functional Requirements

The functional analysis of the IDAMST system was directed towards determination of crew control/display and subsystem imposed requirements on the IDAMST software. The analysis was based upon the mission scenario referenced by Paragraph 2.1a and summarized in composite form by Figure 18. A major task associated with the functional analysis was the generation of operational sequence diagrams (OSD's) (see Volume II of this report). The OSD's served as a disciplined technique to systematically review the AMST mission at a functional level within the context of the established system architecture and the specific IDAMST configuration (shown previously by Figure 6). The OSD's served as the basis for the following information:

a. Identification of mission phases.
b. Identification of mission.
c. Allocation of crew tasks.
d. Identification of crew information display requirements.

This data is summarized by functional category in Figure 19 and has served as the basis for further definition of the IDAMST software functional requirements. The remaining paragraphs of this section (Section 3) will briefly elaborate on each of the functional categories with further detail provided in the IDAMST applications Software Specification SB 4042.

#### 3.2.2.1 Functional Definition (Summary)

Figure 19 has categorized the identified IDAMST software supported functions into six basic functional areas. They are:

a. Flight and propulsion
b. Communications
c. Navigation and guidance
d. Payload
e. Aircraft systems
f. Defense

##### 3.2.2.1.1 Flight and Propulsion

In this functional category the IDAMST system functions provide processed data to crew displays. This includes the pilot's and copilot's HUD's, HSD's and MPD's and the center panel MPD. These displays are moded or reformatted depending upon flight phase.

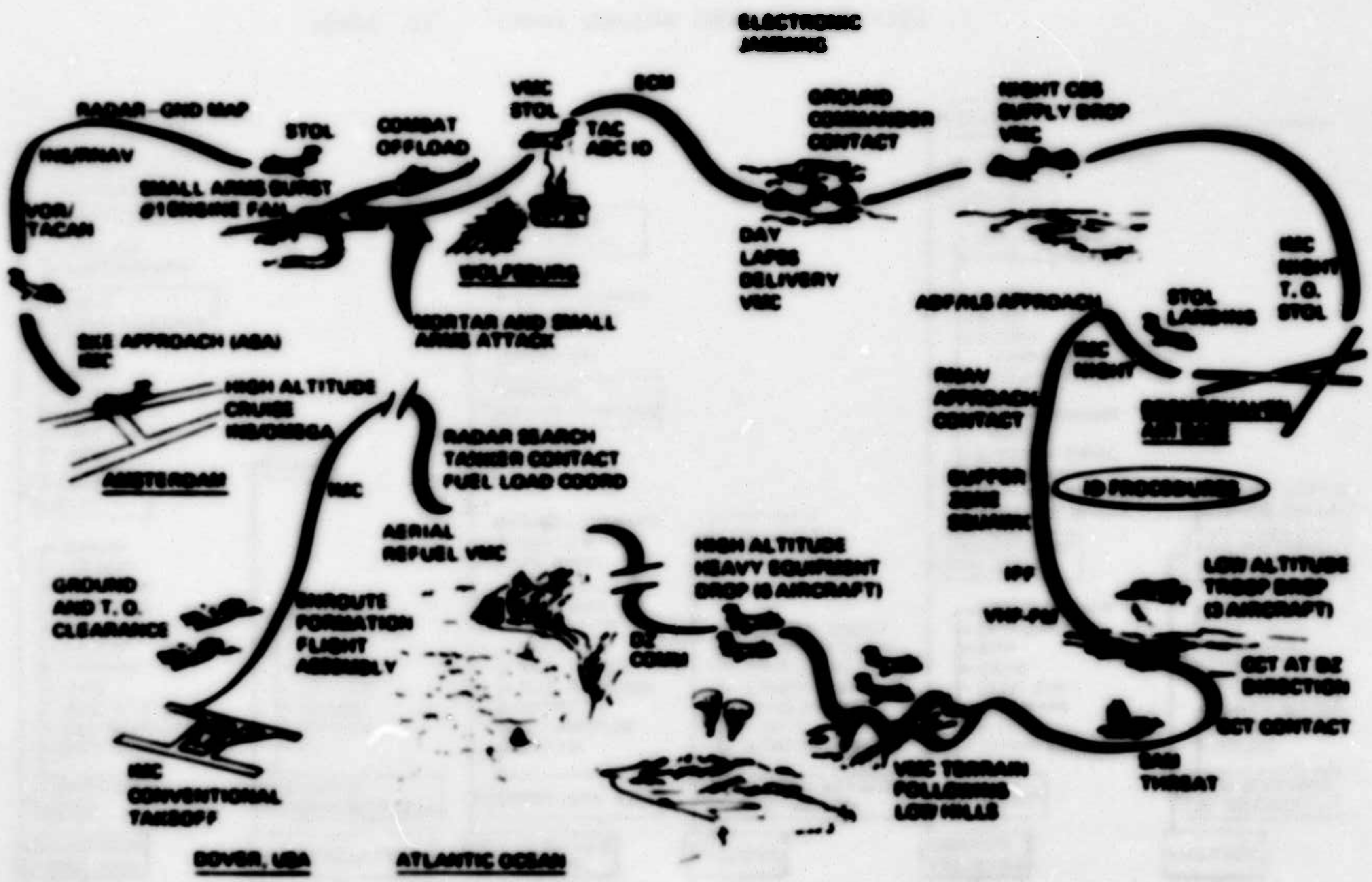



FIGURE 18. IDAMST COMPOSITE MISSION SUMMARY

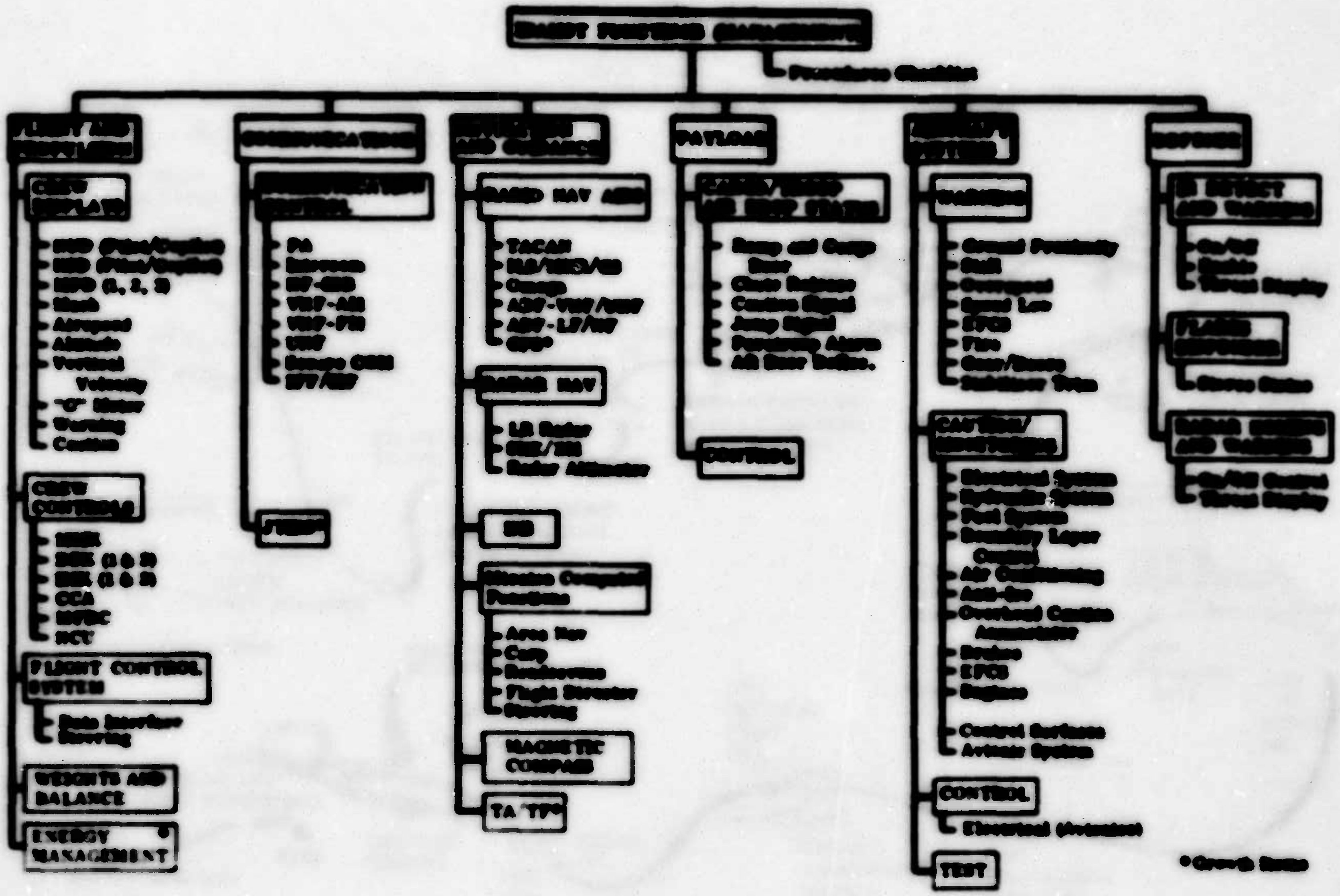



FIGURE 19. IDAMST FUNCTION IDENTIFICATION LIST

For the AMST, based upon the mission analysis, 10 unique mission segments or flight phases have been identified. They are as follows:

a. Start
b. Take Off
c. Enroute
d. Air Refuel
e. Air Drop
f. TA/TF (growth capability)
g. Land
h. Go Around
i. Shut Down
j. Test

These flight phases are controlled by crew selection via the Master Mode Keyboard (MMK) and as stated above selection of a flight phase will automatically reformat the displays with processed data appropriate for that flight regime. Within the IDAMST processors, selection of a flight phase causes a unique sequence of software functions to be executed, to process the required data for display.

Table 8 defines the parameters to be displayed for that mode with an optional (pilot selectable) declutter submode. Table 8 also defines the parameters to be displayed automatically upon selection of any flight mode via the MMK.

Several other examples of CRT displays are given by Figures 20 and 21. These two examples are for the HSD in the HSI and MAP modes, respectively. Each mode is selectable by the crew via the HSD bottom keys. The MPD displays provided by IDAMST are given in Table 9 and are assigned to one of the three MPD devices. These units are designated the pilot's MPD, the copilot's MPD and the center MPD. Table 10 subsequently indicates mode dependency of these displays and are normally automatically selected upon selection of a flight mode.

At the beginning of each flight mode (upon crew selection) a checklist is displayed and upon completion is replaced by one of the designated MPD

TABLE 8 HUD DISPLAY PARAMETER SCHEDULE

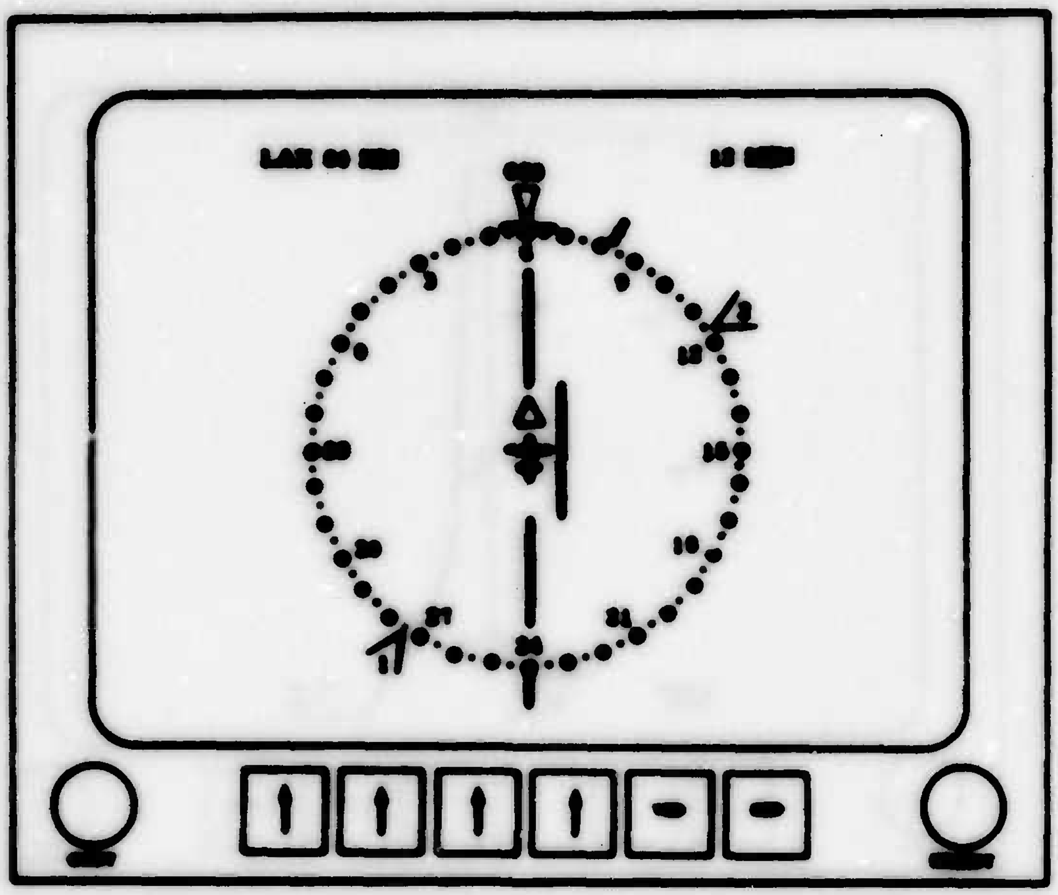


FIGURE 20. HSD-HSI DISPLAY MODE

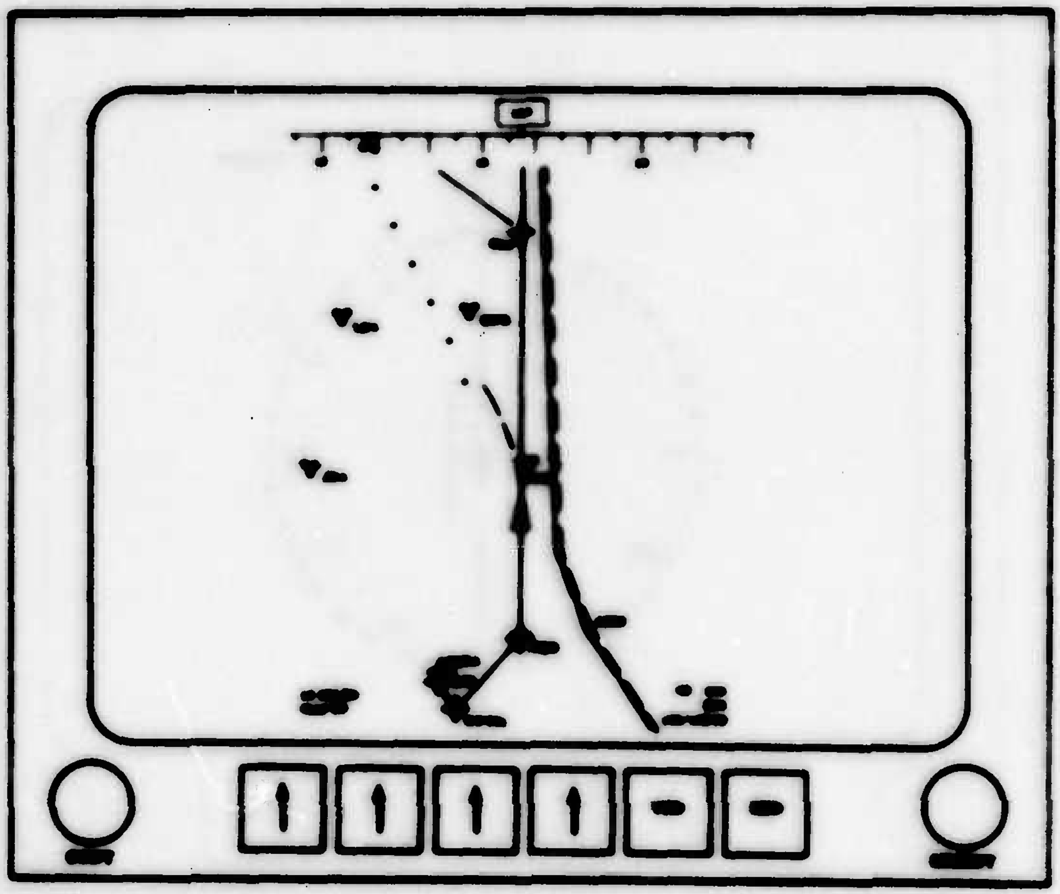


FIGURE 21. HSD-MAP DISPLAY MODE

TABLE 9 NOMINAL DISPLAY VERSUS MPD ASSIGNMENT

| DISPLAY | MPD #1 PILOT | MPD #3 | MPD #2 COPILOT |
|---|---|---|---|
| NAV STATUS | X | | X |
| COMM STATUS | X | | X |
| SYSTEM STATUS | | X | |
| ENGINE PARAMETERS | | X | |
| DEPARTURE AREA DATA | X | | |
| TAKE OFF PARAMETERS | | | X |
| CRUISE PARAMETERS | | | X |
| REFUEL STATUS | | X | |
| AIR DROP FLIGHT PARAMETERS | X | | X |
| AIR DROP AREA DATA | X | | |
| APPROACH DATA | X | | |
| LANDING AREA DATA | X | | |
| WEIGHT AND BALANCE DATA | | X | |
| WEIGHT AND FUEL DATA | | X | |
| FLARE INVENTORY | | X | |
| LOW SPEED PARAMETERS | | | X |
| AIRCRAFT SYSTEMS READOUT | | X | |
| WARNING/CAUTION | | X | |
| FLIGHT DATA | X | | |
| LAPES AREA DATA | X | | |
| RENDEZVOUS DATA | X | | |
| SID | X | | |
| STAR | X | | |
| DELIVERY SYSTEM STATUS | | | |

| [illegible] | [illegible] | [illegible] | [illegible] |
|---|---|---|---|
| [illegible] | * | [illegible] | * |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | * | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | * | [illegible] | * |
| [illegible] | * | * | * |

* [illegible]

TABLE 10 NORMAL DISPLAYS AT BEGINNING OF MODE

displays per Table 10. The crew can circumvent the automatic scheduling of MPD displays by manually selecting the desired MPD display via the IMK.

3.2.2.1.2 Communication

In this functional category the IDAMST system provides functional control over the communication equipment. This control is exercised by the crew primarily by means of the Integrated Multipurpose Keyboard (IMK) and the associated Digital Entry Keyboard (DEK). These devices were previously illustrated by Figure 9. Figures 22 and 23 demonstrate the use of the IMK for control of a UHF transceiver. Figure 22 indicates the IMK readout subsequent to selection of the COMM top key. The display indicates all communications equipment controllable by the IMK. Upon selection of the UHF #1 side key the next level of control selection is displayed as shown in Figure 23. Continuing the example, the operator may then proceed to change the current selected channel (channel 17) to a new channel (channel 20). He would depress the CHAN SELECT side key and enter 20 on the DEK numeric keys and depress the DEK enter key. The IDAMST processor would subsequently initiate action to remotely change the UHF #1 transceiver to Channel 20 and display the update channel number on the IMK. Figure 24 lists all the communications control parameters for the IMK.

A dedicated intercom control panel shown previously in Figure 9 is used to control local headset volumes for the various audio signals available and selection of mic communications (e.g. UHF #1, UHF #2, etc.).

These functions are felt to be inappropriate for IMK usage either because of high frequency of usage or because of the continuous control nature of such functions as volume.

3.2.2.1.3 Navigation and Guidance

An integrated IDAMST navigation system was defined previously in Paragraph 3.2.1.3. The basic navigational functional tasks performed by the IDAMST system are restated as follows:

a. Management of the navigation system.
b. Processing of navigational data.
c. Formatting and display of navigational information.
d. Generation of steering signal for aircraft guidance via the flight control system.

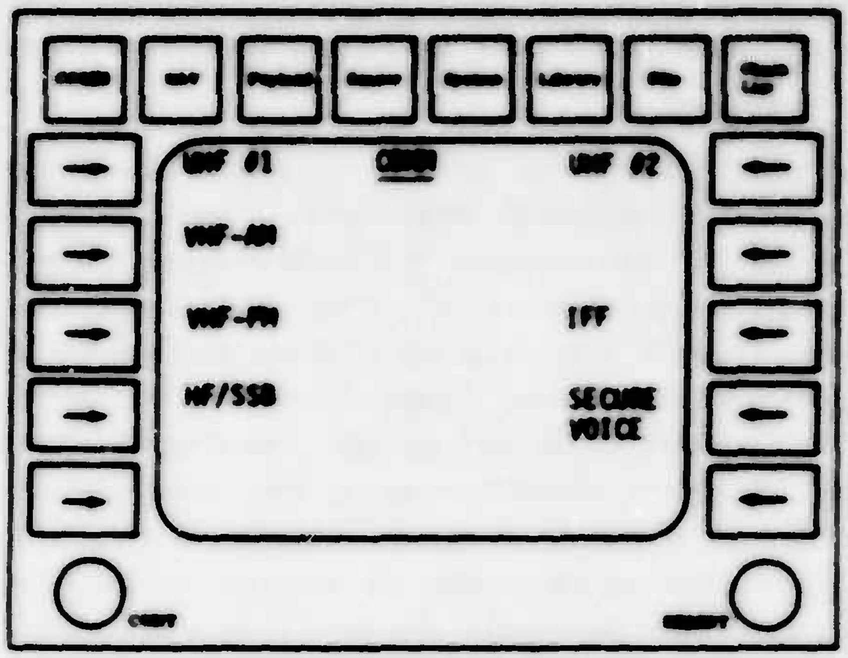



FIGURE 22. IMK COMMUNICATION CONTROL - FIRST PAGE

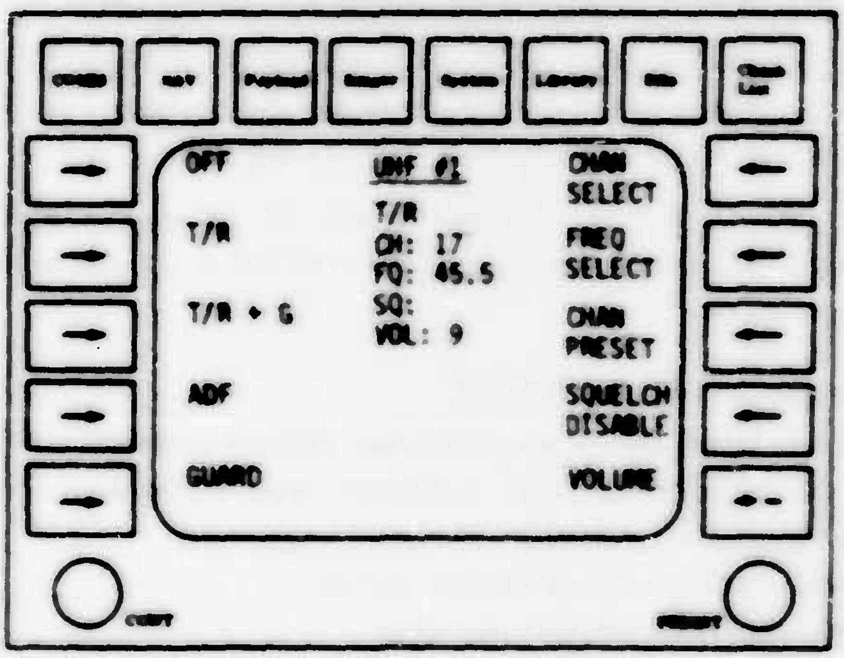



FIGURE 23. IMK COMMUNICATION CONTROL - SECOND PAGE

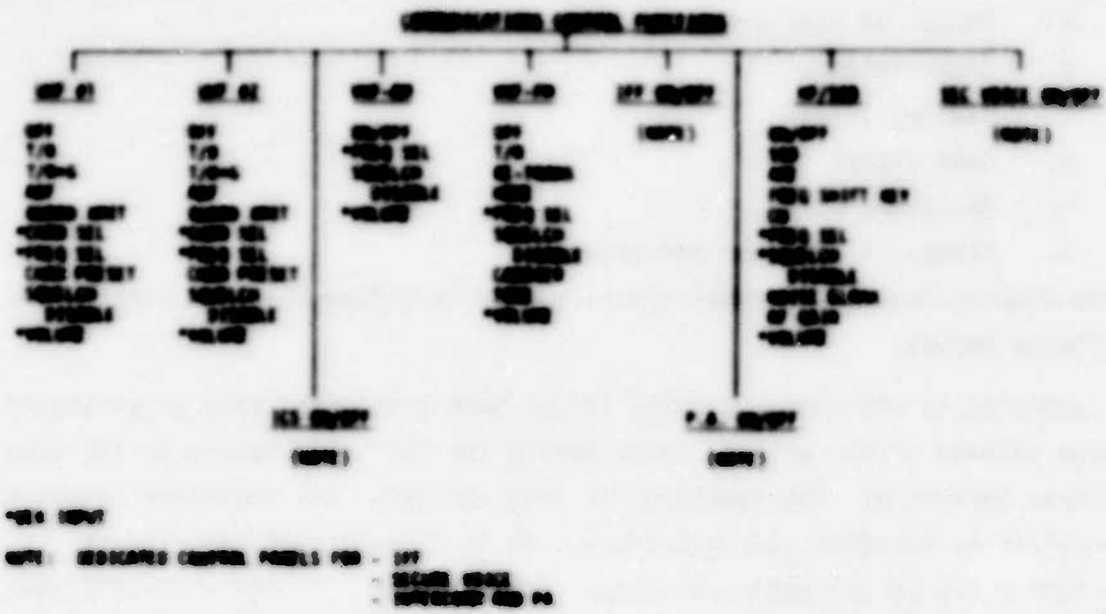


FIGURE 24. COMMUNICATIONS CONTROL REQUIREMENTS

As a part of the navigation management crew control and data inputs are required to the individual navigation subsystems such as the radio aids. The MFK/DEK devices are used for this purpose in essentially the same manner as described for the control of the communication equipment. Figure 25 tabulates the specific control and data entry functions associated with the IDAMST navigation system.

#### 3.2.2.1.4 Payload

For the purposes of this study the payload function is postulated as primarily a status display on the MPD of various parameters associated with the payload such as:

a. Status of ramp and cargo door.
b. Chute release.
c. Caution signal
d. Jump signal.
e. Paratroop alarm.
f. Status of aft door deflectors

This display requires further investigation to define specific content and suitable format.

In addition to the status display it has been postulated that an automatic cargo release signal will be generated by the CARP computation to the load release mechanism. The specifics of this interface are undefined except to speculate on possible configurations. It is assumed that the release mechanism has an automatic and manual release mode. If the automatic mode is selected and armed by the crew then receipt of a CARP timing signal will initiate the auto drop sequence.

#### 3.2.2.1.5 Aircraft Systems

The aircraft systems function is essentially a monitor function by the IDAMST system. The functional requirements fall into three sub-groups:

a. Warnings.
b. Caution/Monitoring.
c. Test.

##### 3.2.2.1.5.1 Warnings

IDAMST will incorporate warning functions either as copied or generated. Copied warning functions are monitored at the flight crew's hardwired

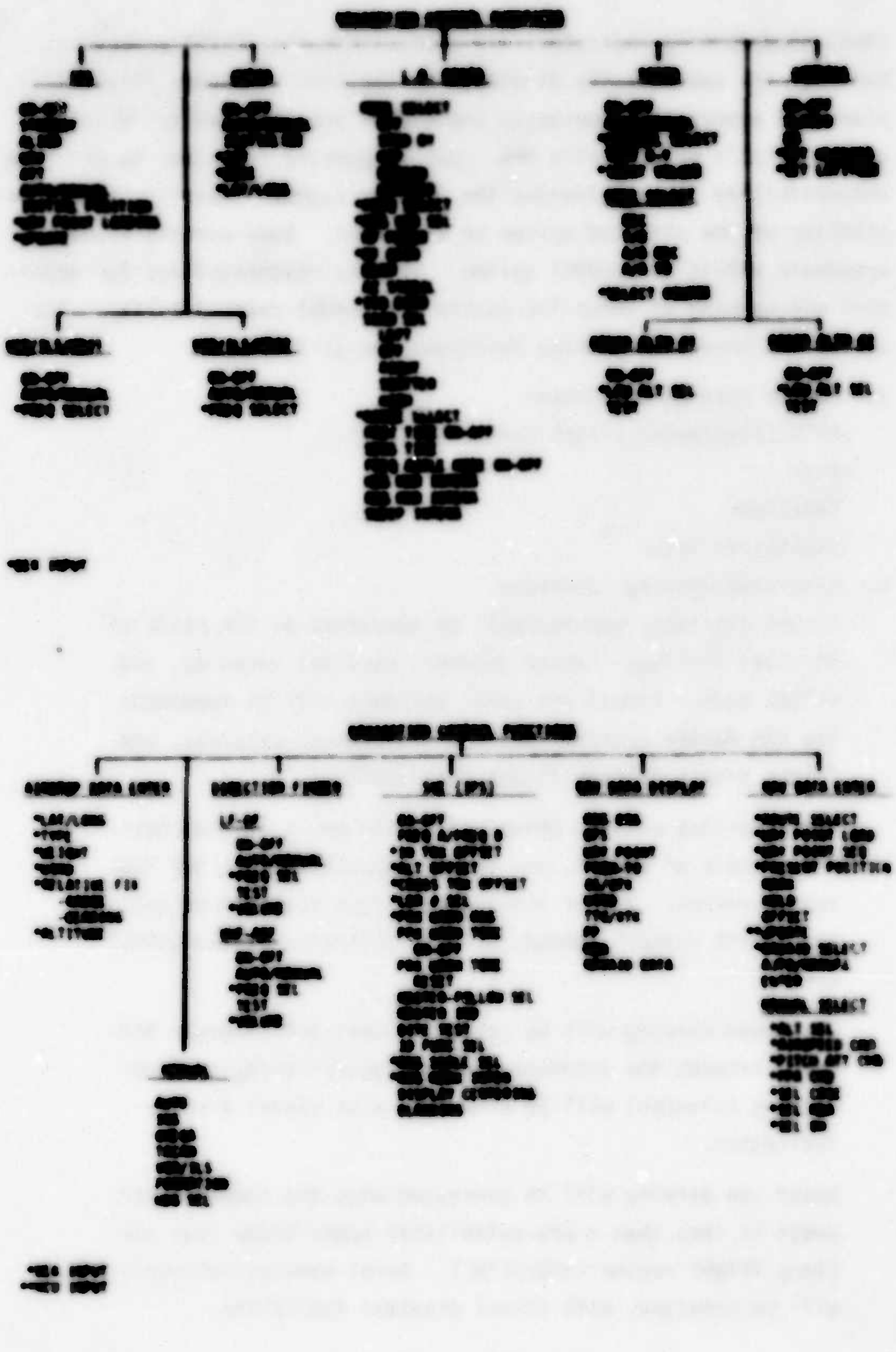


FIGURE 25. NAVIGATION CONTROL REQUIREMENTS

(dedicated) warning indicators and copied into the IDAMST processors. Warnings are subsequently displayed on the crew's primary flight displays and appropriate emergency procedures are selected for display on the pilot's or copilot's MPD. Copied warning functions do not have responsibility for originating the warning signal. This is the responsibility of the affected system or equipment. Some warning signals originate within the IDAMST system. Primary responsibility for detection and warning of these lie within the IDAMST responsibility. The copied and generated warning functions are as follows:

a. Copied Warning Functions:

EFCS (Electronic Flight Control System)

Fire

Gear/Door

Stabilizer Trim

b. Generated Warning Functions:

Ground proximity warning will be generated on the basis of aircraft altitude (above ground), vertical velocity, and flight mode. Visual and aural warnings will be commanded via the Master Caution indicator, dedicated displays, and flight crew's primary flight instruments.

Stall warning will be generated on the basis of flap position, angle of attack, and thrust computations in the STOL configuration. Visual readout on flight instruments and the "stick shaker" command will be initiated by the IDAMST system.

Overspeed warning will be generated when the computer airspeed exceeds the airplane maximum speeds ($V_M/M_M$). Aural warning (clacker) will be provided, with visual display indication.

Speed Low warning will be generated when the computed airspeed is less than a pre-established speed based upon airplane flight regime (STOL/CTOL). Aural warning (clacker) will be provided, with visual displays indication.

3.2.2.1.5.2 Caution/Monitoring

IDAMST will perform caution and monitoring functions for the items noted below. These functions will either be copied (secondary responsibility) or generated (primary responsibility) and are as follows:

a. Copied caution functions. These functions are copied from the hardwired caution advisory indicators in the pilot's-copilot's crew station. Secondary caution signals will be generated and displayed on the MPD's. The functions are copied are:

   Electrical system
   Hydraulic system
   Fuel system
   Boundary layer control
   Air conditioning
   Anti-Ice
   Overhead caution annunciator
   Brakes
   EFCS

b. Monitored functions. These functions are derived from monitor sensors and displays of significant parameters are presented to the crew on the MPD's. They are as follows:

   Engine parameters (N1, EGT, N2, FF, oil pressure and oil quantity)
   Flap position (left- upper surface blown flaps, right-upper surface blown flaps, left inboard flap, right inboard flap and right inboard flap).

3.2.2.1.5.3 Test

IDAMST will incorporate a limited, in-flight test capability by virtue of BITE, software reasonableness test on input data or associated computed values, and correlation of sensor data by direct comparison with redundant hardware or similar hardware. Test data will be recorded on the digital integrated test sytem (DITS) recorder. Selected data will also be transmitted to the Crash Data Recorder (CDR) for recording.

3.2.2.1.5.4 Control

The IDAMST design employs a simple avionics power management capability. Upon initial IDAMST startup the avionics power to the various IDAMST integrated LRU's is sequenced on in a predetermined manner from the mission processors. A dedicated power control panel is also available to provide power control of the IDAMST core elements. The crew can selectively turn power off any LRU via the IMK. A power status report is available to the crew on a select basis.

Although not included in the requirements, the IDAMST system power management capability can be extended to reschedule (shutdown) avionics hardware on a priority basis in the event of reduced aircraft electrical power generation to minimize load.

3.2.2.1.5.5 Defense

Infra red Detection and Warning (IRDAW) capability is part of the basic avionics equipment complement. Associated with this equipment is the flares dispenser for IR counter measures. This system is assumed to be automatic upon crew enable. The IDAMST system function is restricted to control of the IRDAW on/off and automatic operation enable. A threat display and flares stores status is automatically called up on the pilot's and copilot's MPD upon threat detection.

The Radar Homing and Warning capability is a passive device. On/off control is via the IMK. A threat display is evoked on the pilot's and copilot's MPD similar to the IRDAW upon threat detection.

## SECTION IV
## SOFTWARE DESIGN

The IDAMST software design represents the application of DAIS technology to the specific functional, architectural, and configurational requirements of the AMST aircraft. The IDAMST software is designed to satisfy the functional requirements discussed in Section 3, for both normal and failure modes. Architecturally, the IDAMST software is similar to DAIS with some modification and change occurring at the detailed operational level. The specific IDAMST software configuration is by necessity different from DAIS because of the contrast in operational requirements. However, where functional commonality exists, the IDAMST/DAIS structure allows a high degree of reuse of DAIS specified software components.

### 4.1 IDAMST OPERATIONAL FLIGHT PROGRAMS

The IDAMST Operational Flight Programs (OFP) are organized on the basis of DAIS architectural design and divided into three categories:

a. OFP Executive Software

b. OFP Applications Software

c. OFP Error Handling and Recovery Software (EHARS)

This basic grouping of software is shown in Figure 26.

The executive software provides the control of the Applications and EHARS software and isolates or buffers these programs from the mechanism of data transmission between processors and avionics equipments. The Executive software controls this data transmission mechanism.

The Applications software provides the detailed software functions to support the AMST mission and operational requirements as identified and discussed in Section 3. Through the Executive software the Applications software communicates with the avionics equipment, crew controls and displays.

The EHARS software provides system error recovery due to malfunctions detected in avionics equipment, the data communications network or the mission processors. The mechanism for EHARS is distributed throughout the Executive and Applications software.

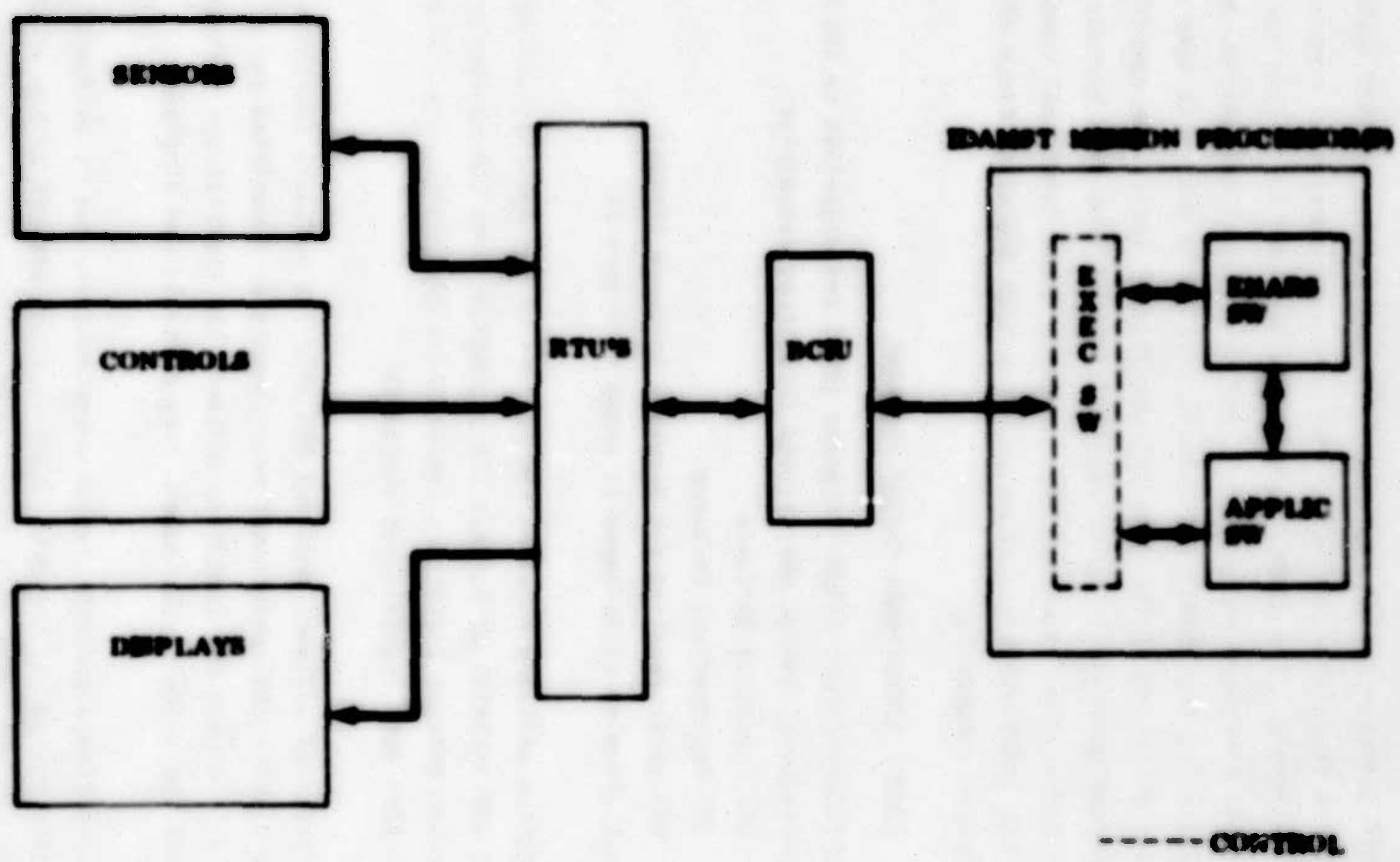



FIGURE 26. IDAMST Operational Flight Programs

### 4.1.1 IDAMST Software Architecture

Although the IDAMST software architecture has been derived from the DAIS architecture there are some significant differences in the functioning of the Monitor Processor. The IDAMST software is distributed among three processors all of which are actively performing mission operations. Two of the three processors have virtually duplicate software. One processor is devoted to processing requests and displays for the pilot and the other is devoted to the copilot. The primary differences between these two processors is that one contains the Master Executive which is responsible for determining if there has been a degenerative failure or error in the other processors and either has stopped processing or must be stopped. The Monitor must then take over control of the data communication network and reconfigure the system to accommodate the failed processor.

During recovery from an error the software in either of the two processors is capable of interfacing with both the pilot and copilot devices. Both the Master and Monitor Processor contain some active and inactive software during normal operation, however, most redundant functions are active to provide an error detection capability.

The Local Executive programs are identical in all three processors, although the task tables contain different entries. The Local Executives are responsible for satisfying the Real Time request of the tasks. The Executive must dispatch tasks when events have been appropriately set either by the clock or by other tasks and must communicate with the Local Executives in the other processors in order to synchronize tasks in all three processors.

The Applications software is organized in a hierarchial control tree structure. The tasks are separated into Controller and Calculator functions. Each task has a unique controller function which is the only task permitted to schedule it. That is, a task can only be invoked by a task at the next higher level of control. However, events upon which the task activation is based can be signalled by tasks at all other levels. A task must be scheduled and activated before it can begin execution.

In IDAMST, the Master Sequencer is the top level controller task (see Figure 27). It schedules the Subsystem Status Monitor, Configurator, and Request Processor. The primary controller of the next level of control is the Configuration which schedules and cancels most of the Equipment Interface functions (EQUIPS), Operational Sequencers, (OPS - next level of control based on mission mode), Brute Force Specialist Functions (BF Specs - next level of control based on pilot requests), Computational Specialist Functions, and Display Interface Functions. The Configurator in the Master Processor is responsible for the control of the Applications tasks in the Master and Remote Processor while the Monitor Configurator controls its own Applications software.

### 4.1.2 IDAMST Executive Functions

The Executive consists of a Master Executive and a Local Executive. A fundamental design objective of the Executive is to isolate the characteristics of the IDAMST hardware from the applications software. The Applications tasks have no information as to its location or the location of any tasks with which it communicates. Task communication occurs via data in compools and via events. Both of these methods of communication are provided by the Local Executive if the compools and events are located only in one processor. If compools and events are within processors other than the one where the Executive services were requested, then the Master Executive is responsible for communicating (in conjunction with the Local Executive) the data to the appropriate processor designated by the Local Executive.

The Master Executive is responsible for controlling all communication between processors and between remote terminals. The Master Executive controls and formulates the commands to the data communications network so all requests for communication must go through the Master Executive. This Executive is the only source of absolute time, and is responsible for initiating each minor cycle and providing the automatic synchronous input and output for each minor cycle by having a list of synchronous commands for each minor cycle. The Error Handling and Recovery modules that are a part of the Master Executive provide for errors with respect to communication and core element failures.

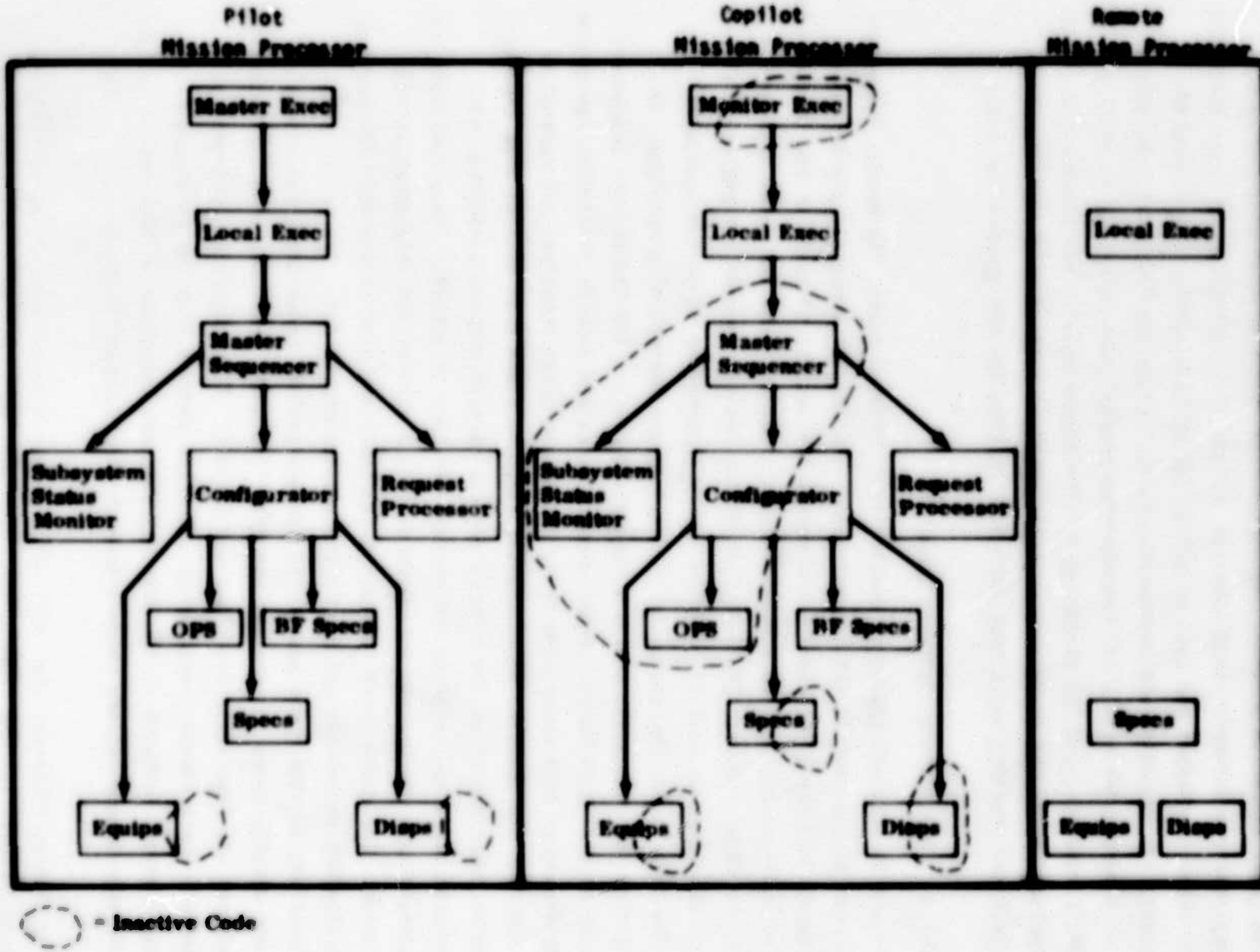



FIGURE 27. IDAMST Software Architecture

The Local Executive provides the normal Real-Time Executive services to the Applications software. Such services include: (a) initiation of tasks according to event conditions and task priority; (b) posting events; (c) scheduling tasks; (d) canceling and terminating tasks; (e) suspending tasks, and waiting for a particular event; (f) transferring compool data according to READ and WRITE requests; and (g) preparing for the beginning of a new minor cycle, which includes preparing to receive and send messages related to a specific minor cycle and invoking tasks that have been waiting for the given minor cycle.

### 4.1.3 Applications Software Structure

Figure 28 outlines the major applications software tasks. The Master Sequencer serves as the root of the control tree. The Request Processor fields control inputs from the pilot-copilot and relays the request if valid to the Configurator. The Configurator acts to schedule, cancel, and activate the tasks appropriate to the crews request. The Subsystem Status Monitor records the status of all of the equipment as well as fielding errors reported to it by the Equipment Interface Tasks. The status of the devices are periodically recorded in storage for diagnostic analysis when appropriate. The Operational Sequencers reflect the 10 different IDAMST mission modes and provide initialization at the beginning of each mode. The Brute Force Specialist Functions are controller tasks for the specific pilot-copilot requests other than mission mode changes. These functions allow the crew to perform certain mission operations not automatically available to the current OPS that is active. These functions operate upon the various equipment that is a part of the integrated avionics system. The Brute Force Specialist Functions are also responsible for setting navigation parameters and displaying various checklists. The specialists functions provide the computations for navigation, cargo drop, and control of some display tasks for the IMK and MPD. Equipment Processes form the interface between the Specialist Functions and sensors. These tasks are designed to isolate the hardware characteristics of the sensors from the remainder of the Applications Software in the same way that the Executive is designed to isolate the data communications network from the Applications Software.

The Display Processes are tasks which output display information to the crew. Display tasks include lights, HUD, HSD, MPD, IMK, and some conventional instruments.

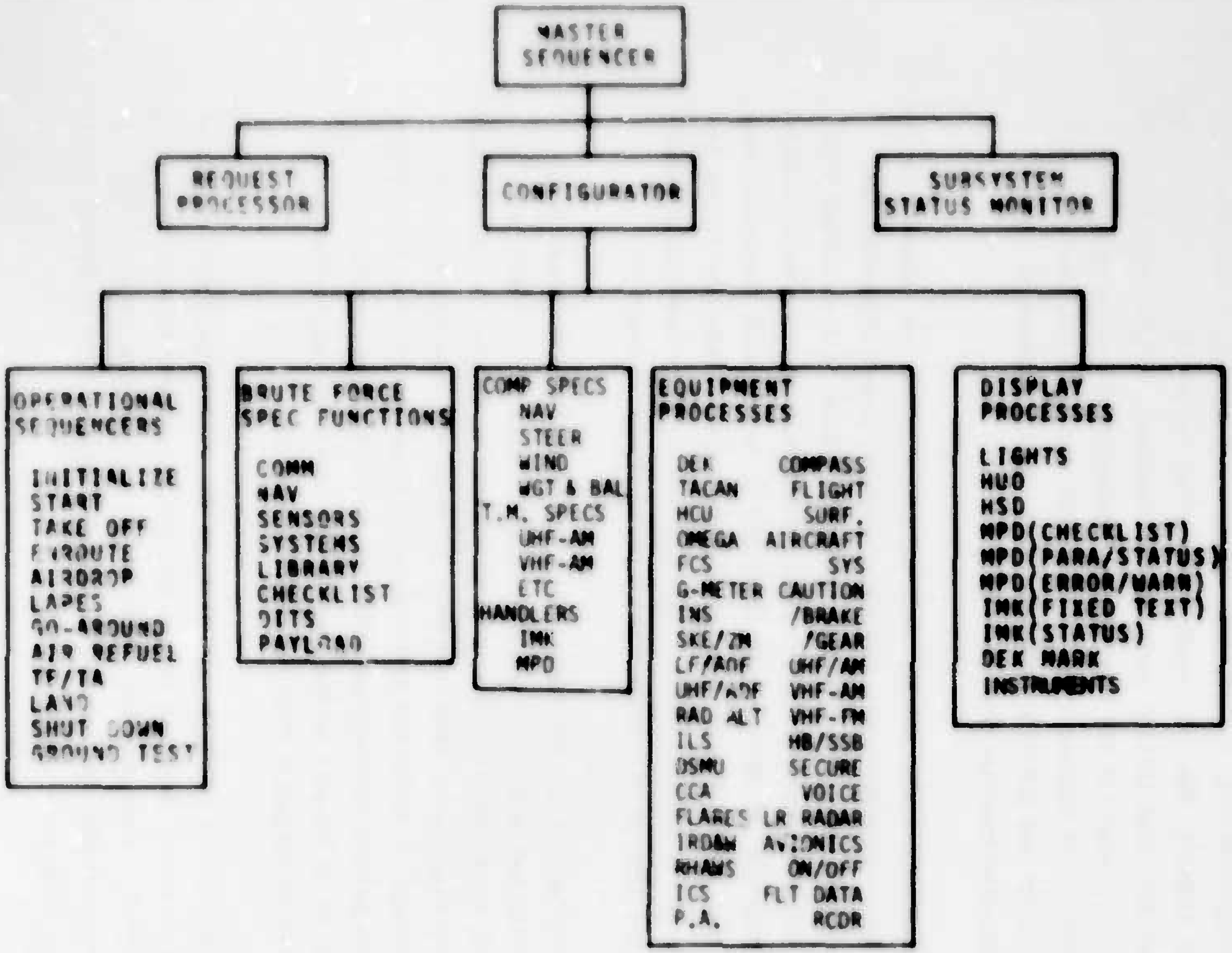



FIGURE 28. Applications Software Elements

### 4.1.4 Error Handling and Recovery Software (EHARS)

IDAMST OFP EHARS is specified for three major functional areas: (a) response to errors occurring internal to the IDAMST mission processors including computer program induced errors, (b) response to errors occurring in the data communications network, and (c) response for errors occurring in subsystem sensors, actuators and crew station controls and displays. Within each functional area, EHARS will accomplish the functions of determining that an error of sufficient severity to degrade system performance has occurred, isolating the suspected subsystem and notifying the top level control program to remove the faulty subsystem/function from service.

Functions implemented within the OFP Applications Programs are responsible for detection of data reasonableness, improper subsystem sensor sequences and incorrect operating modes. The OFP Applications software is also tasked with making comparisons between results obtained from redundant and similar subsystems (e.g., Omega and INS derived position) and is tasked with reasonable rate and response time tests of data where applicable. Errors detected in the subsystem sensors are handled by the OFP Applications software when those errors are not signaled through bus communication error status information.

EHARS processing within the OFP Local Executive is tasked with handling of mission processor and memory BIT detected errors. Cooperating EHARS code is required in the Master/Monitor Executive to respond to processor internal errors in other Remote Processors. EHARS response to processor internal errors will cause the processor in which the error occurred to become passive with respect to data communications. Cooperating EHARS response in the Master/Monitor processor must be to respond to the passive (no response) data communication network or to error response from the errant processor.

EHARS processing within the BCIU Controller of the Master Executive is tasked with handling of errors detected in the data communications network core element BIT. Communication errors detected by the units include data transmission errors, data network message content or sequence errors, BCIU or Remote Terminal failures and incorrect operations.

EHARS must not only detect errors, but it also must have a tolerance to intermittent errors. A portion of EHARS in the form of the Subsystem Status Monitor must maintain a record of the frequency of errors so that intermittent errors can be permitted up to a predefined threshold. Once the threshold has been exceeded, EHARS must be able to formulate requests to the Configurator to cancel Equips functions that communicate with the errant subsystems. The Configurator is responsible for such cancellations because it is the controller for the Equips functions. The Configurator must also request the Master Executive to stop communicating with the errant subsystem.

EHARS may determine that an error has occurred which requires reconfiguration. Such reconfiguration failures include anomalies in mission processors, BCIU's or an instruction executed in a program which results in a detected error condition. The mechanism for reconfiguration will be discussed in paragraph 4.2.

## 4.2 SOFTWARE CONFIGURATION

The software distribution among the three processors must satisfy the functional requirements that have been imposed upon the software. The functional requirements have been discussed in Section 3, and in detail in the OFP Applications Software Specification (SB 4042).

The software must also be configured to be within the constraints of avionics hardware. The size of the programs should be less than 64 K words. The software tasks should be distributed among the processors such that the capacity of the data communication network is not exceeded. The timing of these tasks is important so that the functions receive and use data from the sensors as soon as the data is available, in order that updated data can be output as rapidly as possible.

Software in a system such as IDAMST must be designed for growth. New subsystems and capabilities will be added as the technology develops. The IDAMST software is particularly oriented towards growth, both in the number of processors and in the placement of tasks in processors. The Executive is designed to isolate tasks from other tasks in order to facilitate growth of software. The controller heirarchy is also designed to facilitate growth.

The configuration of IDAMST is oriented toward flight safety and the maintenance of minimum essential operational capabilities by having duplicate copies of the minimum essential software concurrently operational in two computers. The software is essentially identical for the Master and Monitor processors as can be seen in timing and sizing estimates given in Table 11. The Top Level Control systems include both the Executive and the Applications Controller functions. The Master Executive is larger than the Monitor Executive because the Master Executive must control communication among three processors and the Monitor Executive is only concerned with communication between itself and the subsystems. Only the Local Executive is present in the Remote Processor. The distribution of the Applications Software functions are given in Figure 29. The unshaded functions are those which are duplicated in the Master and Monitor Processors. As can be seen in the figure, the primary functions reserved for the Remote Processor are Area Navigation and Aircraft Systems functions. The detailed distribution of the functions is given in Appendix B, on sizing and timing of the OFP software

TABLE 11 IDAMST SOFTWARE TIMING AND SIZING ESTIMATES

| | INSTRUCTIONS Words | DATA Words | NOMINAL EXECUTION TIME msec/sec |
|---|---|---|---|
| **IDAMST Master Processor** | | | |
| Top Level Control | 7800 | 5854 | 304.4 |
| Flight and Propulsion | 1900 | 492 | 16.0 |
| Communications | 1515 | 339 | 1.6 |
| Nav. and Guidance | 4511 | 835 | 6.8 |
| Aircraft System | 3580 | 2200 | 52.9 |
| Defense | 230 | 29 | |
| Misc. | 1500 | 300 | |
| | 21036 | 10049 | 381.7 |
| **IDAMST Monitor Processor** | | | |
| Top Level Control | 7800 | 5470 | 210.0 |
| Flight & Propulsion | 1880 | 492 | 16.0 |
| Communication | 1515 | 339 | 1.6 |
| Nav. & Guidance | 4511 | 835 | 6.8 |
| Aircraft System | 3580 | 2200 | 52.9 |
| Defense | 230 | 29 | |
| Misc | 1500 | 300 | |
| | 21016 | 9665 | 277.3 |
| **IDAMST Remote Processor** | | | |
| Top Level Control | 2500 | 2419 | 108. |
| Flight & Propulsion | 75 | 16 | 3.2 |
| Nav. & Guidance | 5210 | 431 | 14.0 |
| Aircraft Systems | 2700 | 326 | 7.1 |
| Defense | 25 | 6 | |
| Misc. | 400 | 100 | |
| | 10910 | 3298 | 132.3 |

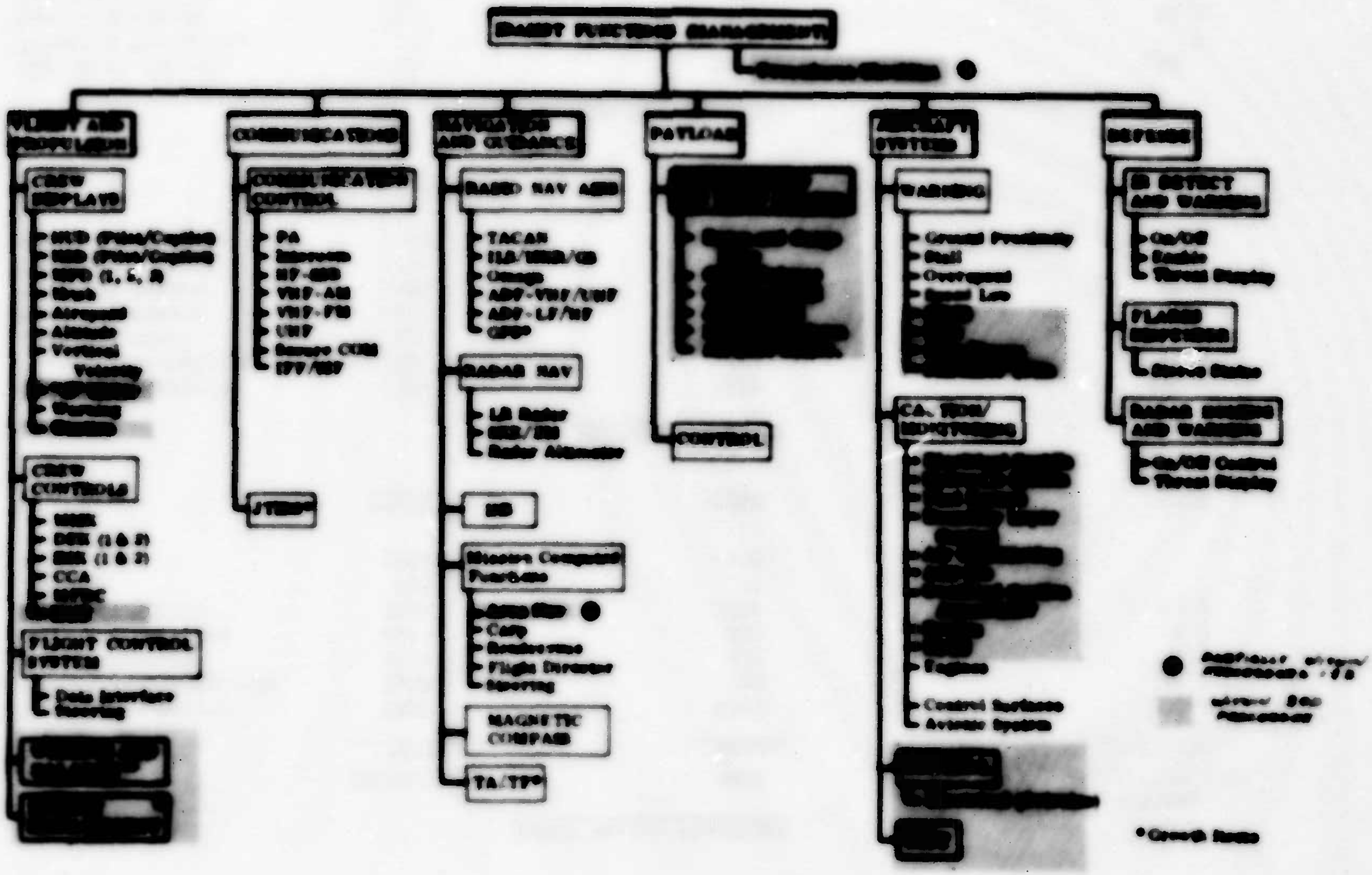



FIGURE 29. IDAMST FUNCTION IDENTIFICATION LIST

### 4.2.1 Mission Requirements for Reconfiguration

The system level requirements imposed on the IDAMST reconfiguration are derived from the mission scenario, and from the operational analysis of this scenario. System level requirements are listed below:

a. Heavy crew workload in a two-man crew environment requires that reconfiguration be automatically controlled. The flight crew is not expected to make diagnostic decisions in determining what system core elements are available and serviceable for inclusion in the altered (new) system configuration.

b. Redundant processing capability is required in a hot-standby mode of operation to provide uninterrupted processing of essential crew information displays and mission-critical functions, despite the presence of mission processor/BCIU failures.

c. The existence of mission-critical crew decision points requires that avionics information displays remain current and accurate despite single-element failures. Examples of mission-critical decison points are:

   CARP in presence of enemy threat where go-around presents excessive risk.

   IMC landing, 50-foot decision point.

d. High-accuracy worldwide navigation capability requirements and conditions causing temporary unavailability of external navigation aides ( such as enemy jamming) require smoothing of navigation calculations by a long-time-constant filter. Requirements to eleminate excessive settling time and maintain overall accuracy require redundant storage of intermediate results and time-dependent data.

e. Crew display information used as the basis for control decisions in controlling the aircraft (e.g., vertical situation, air speed) must be current and updated within the response time of human vision to avoid "jumping" in displays. Display information that is not current, due to system anomaly, must be removed from display (as opposed to freezing) to force the flight crew to revert to dedicated, hardwired backup displays.

f. Mission-dependent data (such as navigation waypoints or cargo ballistics data) and the present system state commanded by flight crew inputs at control panels require redundant computer memory storage to avoid loss of this data due to single-element failures.

g. Multiple device failures, separated in time, and mission-software-controlled mode switching of avionics subsystems requires redundant storage of tables of subsystem status data. Following reconfiguration to circumvent a failed processor, the remaining processors must be able to determine the availability and current mode status of avionics subsystems and effectively continue processing.

4.2.1.1 Architectural Requirements

Additional requirements are imposed on the IDAMST reconfiguration approach by the baseline system architecture and by baseline operating procedures. These requirements are listed below:

a. Two magnetic tape transports are available for possible use in reading redundant copies of flight (OFP) and test (OTP) programs. Typical data transfer rates of this type of device indicate a processor memory loading time for a one-thousand-word program of 0.8 seconds. Mission-critical functions require redundant processor resident storage to avoid unacceptably long interruptions in processing during reconfiguration.

b. Avionics functional capability and flight crew to avionics interfaces remaining after reconfiguration are required to be the same regardless of which processors remain functional. This in turn requires that applications software be activated in remaining processor(s) in such a manner that the same software capability is present in any remaining two or remaining one processor, regardless of the contents of processors prior to reconfiguration.

c. Reconfiguration restoring a full three-processor system (e.g., recovery of the third processor from a temporary power interruption) returns system capability to the normal pre-failure level.

d. Subsystem(s) that have been removed from service as a result of reconfiguration are required to be tested for availability both periodically and on flight crew demand. If declared available by testing and enabled by the flight crew, where sufficient processor capacity exists for associated software the subsystem must be restored to service (by reconfiguration of software if necessary).

### 4.2.2 Reconfiguration Approach

A goal for reconfiguration is that all subsystems within IDAMST be managed in such a manner that the maximum possible capability originally designed into the system be available to the flight crews. This paragraph discusses the reconfiguration approach employed after occurrence of anomalies in mission processors or BCIU's or an instruction is executed in an OFP which results in an error condition.

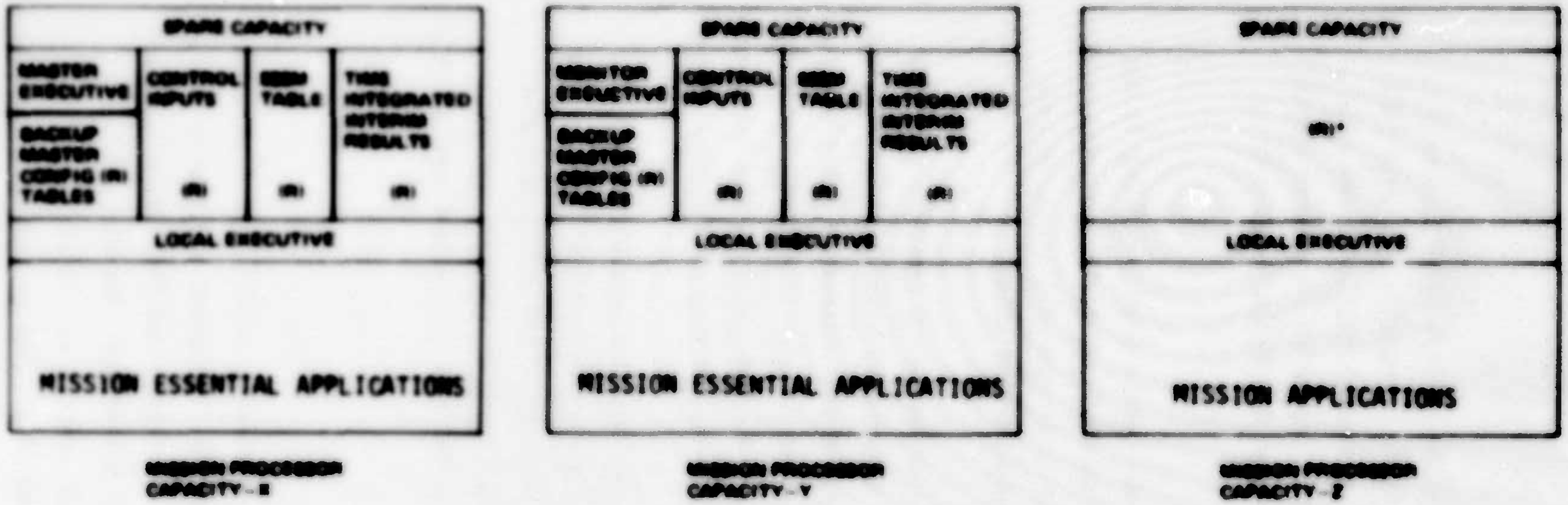
Reconfiguration functions are evoked when normal system error handling is not able to restore the system to the operable state that existed before occurrence of the anomaly. Attempts to return the system to an operable state include retries and attempts to use alternate data communication paths.

Reconfiguration is entered automatically from system backup (monitor function of the OFP Master Executive) operation or can be entered automatically (depending on implementation of the Ground Test Program Master Executive function) from Ground Test Program processing. Reconfiguration uses diagnostic information stored in the mission processor memory during error handling and can supervise additional core element tests to determine availability of the core elements.

Operating under the OFP Master Executive, reconfiguration selects a working configuration of core elements and selects the one corresponding suite of OFP software modules. Reconfiguration supervises loading of OFP software modules from the redundant copy stored on magnetic tape cassette, ensures synchronization of the system and signals consent for switchover to the new configuration to the Master Executive.

#### 4.2.2.1 Initial Configuration

The nominal configuration of the IDAMST OFP software is depicted in Figure 30. The three large blocks represent an analogy of the throughput and memory storage capacity of the three mission computers. This is subdivided (not drawn to scale) into the individual processor capacity used by the Master, Monitor, and Local Executives. OFP Applications in each processor consist of: (a) a cumulative record of crew inputs to the controls subsystem (e.g., Master mode last selected);




*MAY BE USED FOR NON-ESSENTIAL APPLICATIONS BUT IS ASSURED AVAILABLE FOR MASTER/MONITOR FUNCTIONS IN EVENT OF RECONFIGURATION

FIGURE 30. *Reconfiguration Partitioning Scheme, Active Software in Full-Up System*

(b) Subsystem Status Tables; (c) cumulative interm results of applications calculations (e.g., present navigation position); (d) the minimum set of applications tasks that are mission critical or that provide essential display information; and (e) non-critical mission applications tasks.

The Master Executive and Monitor Executive each have a locally resident copy of the backup Master Configuration Tables. These tables include all the Task Descriptor and Data Descriptor table entries that are required to run the system in the single processor, Backup Configuration. The capacity of only one processor is used for Backup Configuration and all active tasks are co-resident in a single mission processor. Figure 29 lists those tasks that are active during Backup Configuration processing to provide uninterrupted presentation of mission-critical information to the flight crew. The duration of Backup Configuration processing is estimated under one minute. Reconfiguration will restore additional capability (depending on the number of available processors) within the time duration of Backup Configuration processing.

4.2.2.2 Transition to Backup Processing

The harbinger of reconfiguration is the reduction of processing from the normal operational system to a one processor system. Both the Master processor and the Monitor processor are tasked with the detection of processor malfunctions. The failure mode for processors is for the errant processor to cease communication with the bus. The Master will detect failures of either the Monitor or Remote Processor and the Monitor will detect failure of the Master processor and associated BCIU's. The Monitor will host the one-processor system and conduct the reconfiguration if either the Master or Remote processors have failed. In the event of a Monitor failure, the Master must assume the uniprocessor configuration and conduct the reconfiguration procedures. The uniprocessor configuration must perform diagnostic tests to determine which of the IDAMST core elements remain operable and must continue to perform the computational and communication tasks assigned to it. At the completion of the diagnosis (less than one minute) and upon a signal from the processor control panel to reconfigure, the uniprocessor will begin the upward reconfiguration if two or more processors are able to function.

4.2.2.3 Transition from Backup Processing to Reconfigured State

An orderly transition from Backup Configuration processing to active processing of the reconfigured Operational Flight Program, under automatic control of the Monitor Executive is provided in IDAMST. Reconfiguration software module loading and state transition to active processing occurs without interruption of the mission-critical functions. Two types of reconfiguration can occur. If the Remote Processor has failed, then no software need be loaded. If either the Master or Monitor has failed, then the Remote Processor must be loaded with a copy of the failed processor's software.

If the Remote Processor fails then the reconfiguration sequence is as follows: First, the Master Processor detects that the Remote Processor does not properly respond to communication commands. Second, the Master turns control over to the Monitor Processor. Third, the Monitor Processor examines the BITE data from the processors and BCIU's to determine the cause of the error. If no error can be surmised, the Remote Processor Software is reloaded and control is returned from the Monitor to the Master. If the failure is confirmed then the Master is signaled to reduce the BCIU command list (message list) to a two processor, Master-Monitor configuration and to set a system flag indicating that a two-processor configuration is in effect.

If the Master Processor fails, then the Reconfiguration sequence is as presented in Figure 31. First the Monitor detects that it has received no minor cycle update for two consecutive minor cycle intervals (1/32 second). Second, the Monitor sets its BCIU to master mode and disables the Master Processor BCIU from transmitting in the master mode. Third, the Monitor Processor begins to activate tasks starting with minor cycle #0 and to communicate with the subsystems. Concurrently, the Monitor must conduct diagnostic tests to determine the operational state of the data communication network. If a power down condition is found and power has been restored, the Master can be restarted. If no hardware malfunction can be detected, then a software error will be assumed. The software will be loaded and verified for the Master Processor, three processor system. If a hardware error is indicated, then the Remote Processor is loaded with the two processor, Master Processor configuration and the Monitor configures its software to run as part of a two processor system (without tape load).

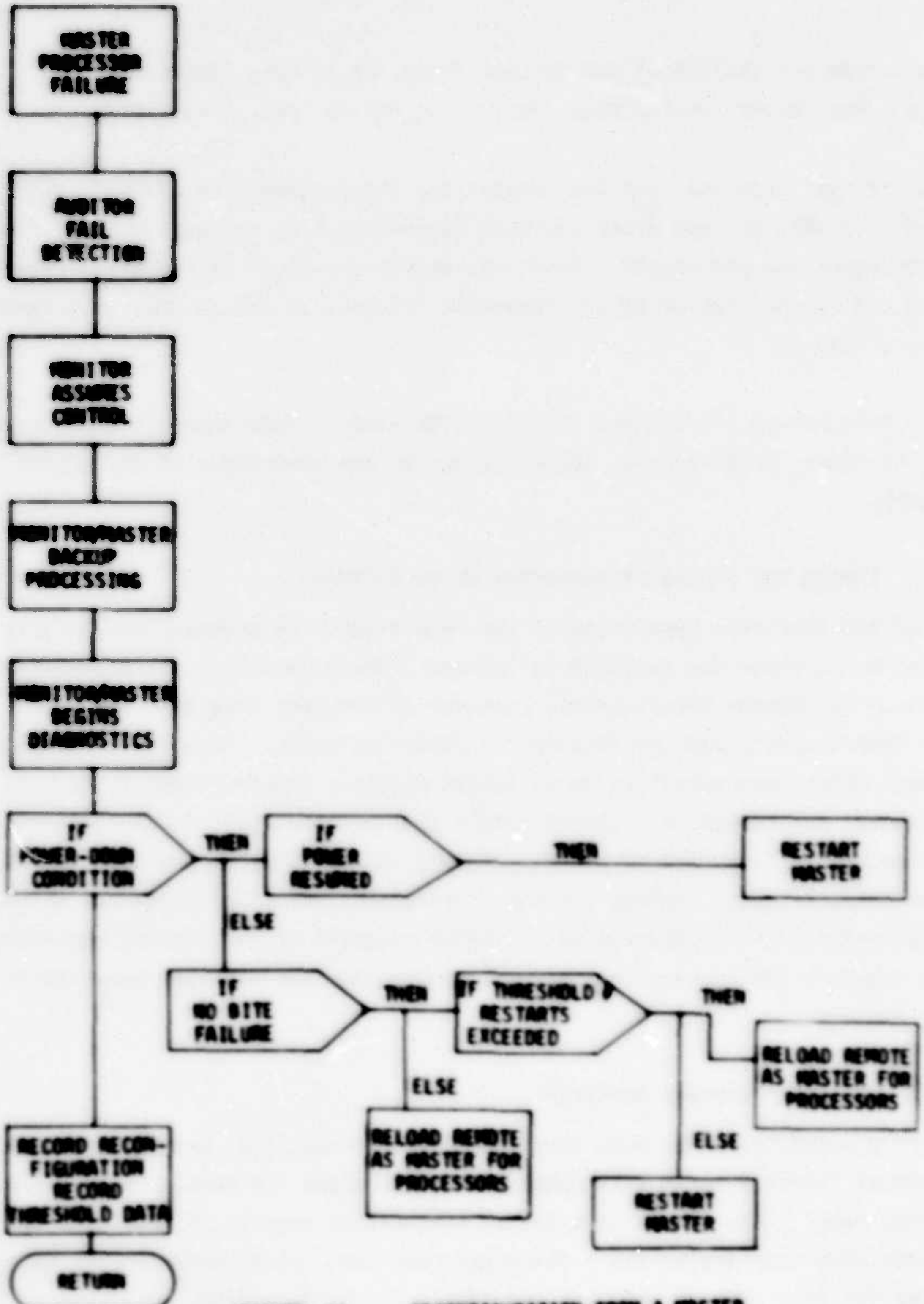



FIGURE 31. RECONFIGURATION FROM A MASTER PROCESSOR FAILURE

Recovery from the failure of the Monitor Processor is very similar to the recovery from the Master Processor failure as can be seen in Figure 32.

The Master can determine that the Monitor has not responded to communication commands. The Master must alter the BCIU command list to exclude communication with the other two processors. From this point, the logic of reconfiguration is very similar to that of Master Processor failure, as can be seen by comparing Figures 31 and 32.

The reconfiguration procedures, including the loading from magnetic tape should be on the order of 16 seconds, primarily due to the slow speed of the magnetic tape unit.

4.2.2.4 Timing and Sizing of Reconfiguration Software

Three of the functions supervised by the reconfiguration software are largely external to the processor in which it resides. These functions are diagnostic testing of the Remote Processor(s), transfer of programs from Mass Memory to Remote Processor(s), and verification of loaded programs. Transfer of programs from Mass Memory and verification of loaded programs requires several hundred milliseconds to accomplish. Approximately four per cent (4%) of bus transmission capacity will be used if the Mass Memory Tape Casette is operated at its maximum transfer rate. During loading of programs, the reconfiguration software is only periodically activated, to determine progress of the loading operation and to sequence the terminal-to-terminal synchronous bus messages required to effect loading.

4.2.2.5 Auxiliary Storage Required

The entire reconfiguration mode load modules for three, two, and one processor Operational Flight Program will cumulatively use about 130 feet of Mass Memory cartridge tape. This figure is based on a recording density of 1000 bits per inch with four data tracks and a fifty per cent (50%) utilization of the tape, to allow for inter-record gaps and redundancy check characters.

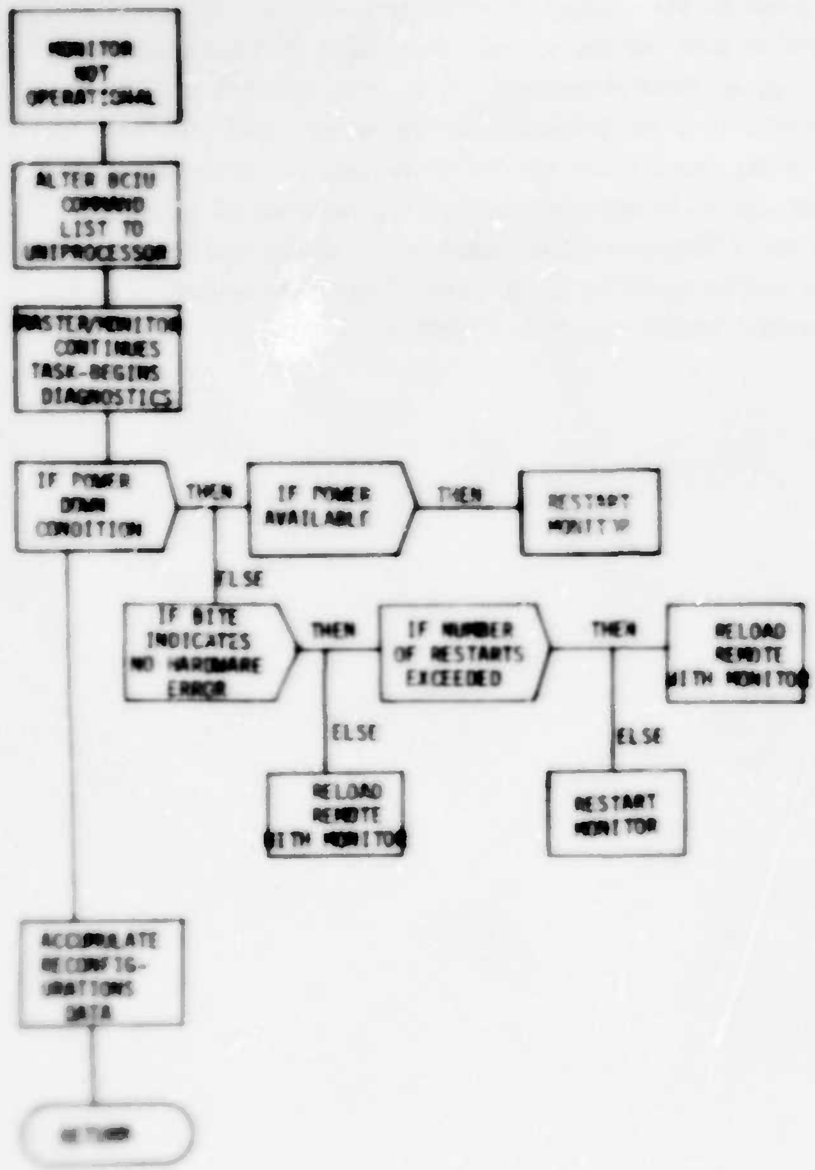



FIGURE 32. RECONFIGURATION FROM A MONITOR PROCESSOR FAILURE

Maximum time to search tape for the required block of data to be read would be sixty-six seconds, at a tape search rate of twenty inches per second. It is reasonable, however, prior to the occurrence of reconfiguration, to position the tape at the section of data for the next most probable configuration. If the system were operating on three processors, it is most probable that a reconfiguration would result in a two processor configuration. OFP code is identical regardless of the identity of the failed processor. Relatively short, processor-unique tables of message descriptors, recorded on tape are required to establish the failed processor(s) identity. Search times for these processor-unique tables would be on the order of one half second, assuming pre-positioning of the Mass Memory cassette is effective.

## SECTION V

## IDAMST SOFTWARE SPECIFICATION

The principal end product of this porgram was to produce four Computer Program Development Specifications, Type B5, as referenced by MIL-STD-490, and per MIL-STD 483 and Section 3.0 of "Appendix H" of the program statement of work. These documents are referenced below.

### 5.1 COMPUTER PROGRAM DEVELOPMENT SPECIFICATION FOR IDAMST OFP EXECUTIVE (SB-4041)

This document specifies the IDAMST Operational Flight Program (OFP) Executive software. The IDAMST Executive is closely patterned after the DAIS executive (Intermetrics Specification SA-201-302) with the following changes of significance. An interface between the Applications programs and the Master Executive (via the Local Executive) has been defined to activate and deactivate communication with devices. The same interface functions will be used also during the reconfiguration of the data communications elements. Global Compool definitions have also been added in order to allow the Applications software more efficient operation. Finally, the BCIU - Master Executive interface has been expanded and clarified, and a BCIU interface function has been specified.

### 5.2 COMPUTER PROGRAM DEVELOPMENT SPECIFICATION FOR IDAMST OFP APPLICATIONS SOFTWARE (SB-4042)

This document specifies the IDAMST OFP Applications software. The DAIS Applications software architecture was used as a basis for developing the IDAMST software to the specific requirements of the AMST. Better than 50% of the DAIS Applications software is reusable for IDAMST with little or no modification.

### 5.3 COMPUTER PROGRAM DEVELOPMENT SPECIFICATION FOR IDAMST OFP ERROR HANDLING AND RECOVERY SOFTWARE (SB-4043)

This document specifies the IDAMST OFP Error Handling and Recovery Software (EHARS). EHARS as an entity in itself is not totally definable. As a result, the number of identified software modules for IDAMST is relatively small. What this document specifies are requirements to be imposed on the Executive and Applications software to incorporate EHARS features into their design.

5.4 COMPUTER PROGRAM DEVELOPMENT SPECIFICATIONS FOR IDAMST OPERATIONAL TEST PROGRAMS (OTP)

This document specifies the IDAMST OTP. It covers both the Ground Test Program -1 (GTP-1) and Ground Test Program - 2 (GTP-2). GTP-1 is relatively straight-forward to define because it is limited to IDAMST core elements (processors, bus, RT's etc.) and the control and display hardware. This core hardware is by nature highly adaptable to self-test and diagnostic. GTP-2 on the other hand, is far less adaptable to automatic testing in a ground test environment. For this reason, GTP-2 requires further study than time would allow. Expansion of the BITE capability of some items of avionics hardware may be necessary. Another alternative is to thoroughly investigate airborne testing of the avionics equipment in an operational environment that cannot be duplicated on the ground without extensive AGE and considerable time.

## SECTION VI
## PROGRAM CONCLUSIONS

Although the specification of IDAMST software was the end result of this program many aspects of the overall avionics system design were investigated in order to establish the software requirements. As a result of these investigations and the software specification process itself, both general and specific conculsions and comments can be made about the IDAMST system design. The general comments are as follows:

a. The IDAMST baseline design will satisfy the AMST operational requirements.
b. The proposed dual redundant processing of minimum mission essential functions with a third processor as backup provides an acceptable level of mission reliability for the AMST.
c. The DAIS system architecture used as a basis for the IDAMST system design provides an excellent point to initiate the design of an integrated digital avionics system.

Specific conclusions and comments will be discussed in *Paragraph 6.2*

### 6.1 GENERAL CONCLUSIONS AND COMMENTS

#### 6.1.1 IDAMST As An AMST Avionics System Candidate

The IDAMST design will satisfy the AMST operational requirements. The hardware and software design satisfies the minimum mission essential requirements, provides growth and system monitoring features that will facilitate operation of the AMST with a two man crew. However, the fundamental questions that immediately arise are:

a. Is the IDAMST configuration required for an AMST operated by a two man crew?
b. If not required, what is?

In the course of the system analysis which was performed during this program, it was apparent that some degree of integration would be necessary to support performance requirements as well as a two man crew. The need for processing capability, especially in the navigation system is a requirement. Also air data computations, system monitoring functions and the consideration of automatic test capability require on-board processing.

These immediate considerations coupled with future requirements such as GPS and JTIDS all strongly dictate the intelligence of an integrated system design. One element of such a design is the efficient transmission of data between sensors, processors, and crew control and display. A communication network (per MIL-STD-1553A) which provides such a means of efficient data transmission with growth capability is necessary. The IDAMST baseline design utilizes multiple processors, a data transmission network and integrates the essential function of navigation, communication, and system monitoring, hence the question is whether IDAMST is the optimum design.

Austerity of cost in procurement is the strong factor that tempers the offered advantages of a DAIS "like" design approach to the AMST. At present, life cycle cost (LCC) counter arguments are not of sufficient tangibility to offset the spector of initial procurement cost by reduced operational costs. Using procurement cost austerity and a definition of minimum essential mission capability as key evaluation factors for IDAMST, it would appear that IDAMST is notthe optimum design almost by definition. It is a system that is initially more expensive and provides more than the minimum mission essential capability.

If IDAMST is not optimum, then what design is? As a purely subjective comment from this study it is strongly felt that a design that has multiple processors, an integrated data communication network (bus structure) and integrated controls and displays is required. IDAMST, as an avionics system type satisfies this criteria qualitatively with only the question of detail left open. To be specific: How much integration is necessary? How extensive is the use of CRT type displays? What processor capability and how many are required? The questions suggest the final comment. Studies that remain can be directed towards detailed analysis intended to answer the immediately preceding questions by using IDAMST as the point of departure.

### 6.1.2 Dual Redundant Processing for IDAMST

A dual redundant processing design was configured for IDAMST. One processor is designated as a pilot's processor while the other the copilot's. Redundant and active software is processed in each of these components.

Functional separation is maintained between the pilot and copilot controls and displays through the processors out to redundant sensors when redundant hardware is so provided. Failure of either processor will not reduce the minimum mission essential capability but will void functional separation. The third processor will, if allowed by the crew, reconfigure and restore functional redundancy and separation. This design is felt to be conservative and as a result require more processor capability and potentially a higher degree of bus traffic than other configurations. The approach is one of the significant departures from the DAIS software configuration. However, it is this conservative approach that simplifies reconfiguration, and is felt to be a step towards descoping the IDAMST system design to a more austere design. Also, it is felt that the requirement for three mission processors is put into proper prospective from a mission reliability viewpoint. It may be argued that perhaps only two processors would suffice, however, this argument can be countered if the third processor is specified as a test processor for automatic test support. In the proposed IDAMST three processor configuration, the aircraft systems monitoring capability is in essence a prerequisite to a test computer. That it can also be used as a backup mission processor improves the mission reliability.

### 6.1.3 DAIS Architecture As Applied to the AMST

The DAIS architecture including the structured approach to the software design proved to be readily adaptable to the AMST when considering an integrated digital avionics design. As a model DAIS served its purpose well by providing a point of reference to trade up or down. It was definitely felt that some features of the DAIS software design while providing flexibility also levied high penalties in terms of excessive throughput overhead burdens and memory requirements. However, the point to be noted is not the inefficiencies, but the relative ease of reducing the inefficiencies for a specific application. This was done for the IDAMST design without destroying the basic DAIS design integrity. Specification of IDAMST software was accomplished in many cases where commonality of functions existed between DAIS and IDAMST by adapting the DAIS specification. Certainly at the B5 software specification level a high degree of reusable software definition through the media of documentation does exist. It is felt that regardless of the final software code implementation, DAIS as a model for software specification of an integrated digital avionics

system design can be used to facilitate the software specification process. This is especially true if the specification can be maintained in a common higher order language through progressive levels of detail. Reusable software at the object code level is not a tangible objective, however, reusable software at the documentation level is obtainable.

6.1.4 Deviations from DAIS

IDAMST assumed the DAIS architecture except for five notable exceptions which are Boeing innovations and are not necessarily in agreement with the AFAL baseline design. These changes were dictated both by our attempt to best satisfy AMST requirements and by increased familiarity with the DAIS architecture. The summary of the commonality of the software between DAIS and IDAMST is presented in Figure 33.

6.1.4.1 Monitor Processor

The most obvious change to the DAIS architecture is the use of the monitor processor in IDAMST. DAIS uses the monitor processor as a passive backup device which contains the minimal functions to support a mission and to support reconfiguration. The monitor processor in IDAMST is an active processor which contains a set of software that is almost duplicate to the master processor, offering a dual redundant processing capability. The master processor responds to the pilot's commands while the monitor processor responds to the copilot's commands and provides the active redundancy apparent in the pilot and copilot. A duplicate configurator resides in each processor which controls the processing activity relative to the individual pilot/copilot requests. These configurators must synchronize on any shared functions in the remote processor, since these functions must be considered as a shared remote resource.

Since either the master or monitor is capable of completing a mission, reconfiguration consists of reloading the system so that a master and monitor are available if two processors are operational, and either a master or a monitor if only one processor is operational.

6.1.4.2 Expanded MIL-STD-1553 With Broadcast - Reception Capability

The IDAMST system expanded the defined performance of a MIL-STD-1553 data communication network to provide a non-responding broadcast reception (listen) capability. The active redundant processing in IDAMST requires duplicate information from sensors to be passed to the master and the monitor processors.

FIGURE 33

IDAMST/DAIS SOFTWARE

COMMONALITY/USABILITY

| | |
|---|---|
| EXECUTIVE SOFTWARE | 85% COMMON |
| APPLICATIONS SOFTWARE | |
| o OPS | 20% USABLE* |
| o SPECS | 38% USABLE |
| o BRUTE FORCE SPECS | 85% USABLE |
| o TAILORED MODE SPECS | 70% USABLE |
| o DISPS | 43% USABLE |
| o EQUIPS | 60% USABLE |

* LESS 20% MODIFICATION

Without the capability to listen, bus traffic becomes unacceptably high because of the large number of duplicate messages.

This expanded broadcast capability does not conflict with the requirements of the MIL-STD. The added performance is limited to the intelligent devices (IDAMST mission processors/BCIUs). The BCIUs will decode and store in the processor's memory all messages occurring on the bus addressed to a defined set of addressees. When operating in this mode, the BCIUs maintain all normal error detection with the exception of a status word response at the end of a message with a listen address.

6.1.4.3 Levels of Control

The DAIS architecture provides a sophisticated mechanism of hierarchial control, in which each task has a controller task. The termination of a controller terminates all of its controlled tasks. IDAMST, because of its simplified architecture, needs only two controller tasks, namely the configurators in the master and monitor processors. This single level of control does not require the sophisticated mechanisms of termination and geneology available under DAIS.

6.1.4.4 Device Control

DAIS does not provide any mechanism to terminate communication with a device which has failed or which is not required. While IDAMST synchronously communicates with all of its devices, error processing dictates that a device (remote terminal) which is malfunctioning and reporting the error over the bus be able to be removed from the bus communication list. Similarly, if bus A malfunctions a mechanism is required to change the communication list to communicate over bus B. It is also desirable to be able to engage and disengage high communication (low use) frequency devices such as the IMK and HCU if bus loading becomes excessive. EQUIPS that detect error conditions through BITE and out-of-tolerance data should also be able to report errors (indirectly) to the executive so that communication with these devices can be terminated allowing a redundant (non-communicating back-up device to be activated).

6.1.4.5 Display Functions

DAIS provides DISP tasks which correspond to individual display variables. Because of the executive overhead involved in the support of tasks, IDAMST grouped all display variables corresponding to a particular display device into a single DISP, reducing the potential number of DISPs from 200 to 10, which can be seen in Table B-6.

## 6.2 SPECIFIC CONCLUSIONS AND COMMENTS

The following conclusions and comments are directed at specific tasks or items encountered during this program.

a. Use of functional sequence diagrams (FSDs) as a systematic technique for yielding software requirements within a DAIS "like" baseline is mechanically a tedious process. It was observed that the analyst tended to become absorbed in the mechanism of drafting the FSDs at the expense of efficiently conveying specific software requirements to the software engineer. The FSDs in themselves are not an efficient media for transmission of software requirements. The DAIS structuring for hardware and software extended to the structuring of software functional requirements suggests that perhaps the process can be facilitated mechanically through a better graphical or perhaps a computer based language. The difficulties encountered suggest a better technique should be searched for.

b. Considerable additional work remains to be done in the area of operational test software, specifically Ground Test Program - 2(GTP-2). The absence of sophisticated BITE capability in some current hardware and the constraint of a ground test environment for testing cause significant limitations to the potential effectiveness of GTP-2. An equivalent automatic test capability comparable to GTP-1 for core hardware for the avionic hardware should be an objective. One possible suggestion is that GTP-2 be extended to an airborne test capability and the benefits of an operational environment be used to systematically test the avionic systems and perhaps the aircraft systems in general. The practicality of this suggestion needs to be investigated.

c. Analysis of the IDAMST system baseline and consideration of a minimal capability suggests that the sophistication of the data communications network design could be reduced to reduce cost and still not greatly impact system capability.

d. The Software Management Plan originally provided by appendix "H" of the statement of work provides a foundation for developing an IDAMST Software Management Plan. A number of modifications to this plan have been incorporated and are contained within the final submitted Software Management Plan. These changes are consistent with comments made in the Interim Technical Report. An alternate approach was also briefly outlined in the Interim Report, but discarded because of the magnitude of effort required to accomplish the task. This task would have clearly detracted from other program tasks, however, the comments pertaining to the alternate plan still are applicable. These comments have been excerpted from the Interim Technical Report and placed in Appendix C of the report.

APPENDIX A

IDAMST SYSTEM ANALYSIS

## 1.0 INTRODUCTION

The IDAMST system was developed using conventional avionics, therefore, a comparison to the non-integrated system architecture is relatively easy. The benefits of such an analysis is that a system designer can measure the level of effectiveness of the selected architecture providing him an indication of where the greatest delta change can occur. Table A-1 provides a comparison by hardware count of the various units in the IDAMST system versus the conventional non-integrated approach.

TABLE A-1

IDAMST vs CONVENTIONAL NON-INTEGRATED SYSTEM

| | IDAMST | CONVENTIONAL |
|---|---|---|
| Avionic Sensors | 221 | 221 |
| Processors | 3 | 9 |
| Remote Interfaces | 11 | 2 |
| Controls and Displays | 61 | 125 |
| | 296 | 357 |

Obviously, the avionic sensors do not decrease, because of integration per se. However, technology improvements in concert with integration will allow reduction or replacement of sensors. This program has taken advantage of such by removing the Doppler radar, attitude heading and reference system (AHARS), and Loran and replacing them with newer technology sensors or redundant sensors available to the IDAMST system through integration. It should be noted that this reduction is very modest in IDAMST and in itself is not a major factor for integration. However, there is an advantage to having an IDAMST architecture, where avionic sensors are concerned, because changes as described above can be made with minor air vehicle impacts. This is due to flexibility and the built-in growth potential of the IDAMST architecture. This is in contrast to the major rework required to add or modify existing sensors in a conventional non-integrated vehicle.

Processor types differ greatly in these two systems. The conventional system consists of nine different, dedicated special purpose processors, while the IDAMST system contains three general purpose, identical processors. The IDAMST processors are identical in hardware and similar in software to the DAIS processors. The selection of this processor type is in keeping with the standardiza-